THE

POPULAR SCIENCE REVIEW.

A QUARTERLY MISCELLANY OF ENTERTAINING AND INSTRUCTIVE ARTICLES ON SCIENTIFIC SUBJECTS.

EDITED BY JAMES SAMUELSON.

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INTRODUCTION.

THERE is a tale told of a wealthy farmer who had a lazy and improvident son, whom he called to his bedside in his dying hour, to inform him that in a certain part of his farm he had concealed a treasure. Before he had time, however, to state the precise locality in which it was hidden he was overtaken by death, and prevented from completing the revelation.

The narrative goes on to say that as soon as the old man's spirit was departed, the son delved over every portion of his farm in search of the treasure; and in order the better to conceal his object, he at once caused the soil to be prepared for the sowing season. The precious hoard was nowhere to be found; but owing to the thorough tillage to which his land had been subjected, his first crop was so prolific that it encouraged him to further industry; and growing in substance, he forsook his indolent ways and became a wealthy and respected yeoman.

This story, which is no doubt familiar to most of our readers, is remarkably figurative of man's progress in scientific knowledge. There is another father; and one of the means employed by Him to develop the noblest powers of his children (often turning them from evil to good courses), is the appeal to their love of gain. A moment's consideration will suggest to every thoughtful reader familiar illustrations of this truth, and we venture to say that every number of this Journal will contain statements of facts by which it will be corroborated.

One example, however, appears to us more striking and appropriate than any other, and it is this:

The desire to become possessed of immense treasures induced the representatives of science, in former times, to deny themselves almost every earthly enjoyment. Secluding themselves

from society, they pored over philosophical works, and passed whole days and nights in experimenting upon the elements, and in submitting the baser metals to every conceivable process, with a view to their conversion into gold.

We have his picture before us—the old alchemist! There he sits in his vaulted chamber, upon his carved, high-backed arm-chair. His head, of which little else is visible than his long flowing hair and beard, leans upon his left hand, whilst with the right he turns over the pages of some mouldering volume in search of the "hidden treasure." Around him may be seen the emblems of his craft. In one corner is a small furnace, fitted with a primitive pair of bellows, on which stands an iron still. Mortars, pestles, crucibles, air-pumps, weights and scales, flasks, funnels, pincers, jars, and vessels of every kind lie scattered about in confusion. On a board or rude table, surrounded by these appliances, sits *the* great black cat, and, suspended over the head of the hoary philosopher, the stuffed owl with outspread wings sways gently to and fro.

They never found the hidden treasure, these misguided but persevering workers, but they broke through the hardened incrustation of ignorance in which mankind was buried in their day; and it was left for their posterity, for practical men of science, to prepare the soil, sow the seeds, and reap the golden harvest. And what, after all, was the object they sought to attain, compared with the indirect results of their labours? They desired to convert the baser into the more valuable metals.

This has since been accomplished; but so much more wonderful have been the other victories of science, that this one is barely known to the world. Who cares to be informed that whole services of plate which grace the banquets of the affluent have been wrought from silver extracted from the crude ore of lead? or that the brilliant ornaments of aluminium which adorn the persons of the fair have been tortured from a lump of despicable clay?—ay, from the meanest soil whereon you trod, and which was not deemed worthy of your regards, profound philosopher and alchemist!

What, we ask, are these benefits compared with the magic influence which lulls the sufferer to sleep and spares him all the anguish of a painful operation? or with the silent messenger that speeds from land to land with news of life and death, of peace and war, outstripping Phœbus in his course; or to the vapoury element which, when confined and controlled, bears its master on his journeys over land and sea like some mighty "Genius" of the East; or, in the stillness of night, conveys intelligence, borne on the wings of lightning from the farthest corners of the earth, and, multiplied indefinitely by this self-same power, to the home of every family throughout the length and breadth of the land.

But there is still another lesson of importance suggested by the simple story of the farmer's son.

He delved with a view to enrich himself alone, but the fruits of his toil supplied the wants of many. So has it been with regard to science. Had some alchemist been enabled through a mysterious process to convert the baser metals into gold, he would have amassed enormous stores of wealth, and with them hoarded up the secret of their production, and carried it with him to the grave.

But it has been wisely ordained by Providence that the spread of knowledge should be gradual, not only in this, but in every other particular; and the unfolding of nature's secrets has necessitated the united efforts of many minds. The principle of combination, whilst it has lightened the labours of the student, has aided materially to enrich our stores of knowledge, and the greater the harvest becomes, the more numerous will be the husbandmen. The men whose avocation it is to penetrate nature's secrets, do not now, as formerly, work alone, secluded from the world, and surrounded by mysteries impenetrable to the vulgar gaze, as were their ancestors. They vie with one another in imparting, not in concealing, information; and the thoughtful sage who spends his nights in study may be seen in the broad light of day rambling through country lanes surrounded by anxious inquirers—youths and maidens, the aged

and young—all anxious to secure a little of the knowledge which he has secured at the cost of so much toil, but now dispenses with such a liberal hand.

Indeed, the reserve of bygone days has passed away, the patent for man's wisdom has expired, the microscope and telescope, the printing-press and all the other aids to scientific progress, are the guide-posts to the traveller on the road to knowledge.

But still the path of the adventurer who dedicates his noblest powers to science is far from smooth. Departing from the shores of the "great ocean of truth" (as the wisest man of modern days has called the province of research), he commences the ascent of one of the precipitous acclivities that rise on every side. Here, as he scrambles up from rock to rock, each step he mounts places within his reach fresh works of interest and wonder. These he collects, and, wearied soon with his exertions, stops to rest. But only in one sense does he rest. Adventurers less active than himself are scrambling up the heights, and cheerfully he lends a helping hand to each as he approaches. And should he, looking down, perceive some undecided pilgrim, doubtful whether the reward is worth the venture, he casts the waverer a hard-earned treasure to lure him on, and show how tempting are the prizes that await him if he persevere.

And then he contemplates the glorious scene around, and in the widening prospect finds fresh courage to resume his upward course.

Onward he goes, and at each turn he finds fresh treasures, meets with new surprises, and a still extending prospect.

'Tis true, the higher he mounts the fewer are his comrades; but then the atmosphere becomes more pure and more invigorating, and greater his anxiety to reach the summit.

At length it is attained; the final effort being perchance the greatest; but what a recompense rewards his arduous ascent!

Beneath him roll majestically the clouds that hid the clear

expanse which now spreads out in purest azure overhead! He sees the limits of the mist that often well-nigh blocked his path, and still envelopes his less nimble fellow-travellers; whilst at his feet lie many provinces and departments, all grouped in harmony and constituting Nature's realm.

What next!

Shall he, exhausted, lie him down and rest upon the summit? contemplate with indifference the fruitless efforts of those who seek to follow in his track? or smile contemptuously upon the ignorant flounderers in the pools below?

No! no! If he but raise his head and gaze into the infinite blue dome above, he will perceive the approving Eye that watched him in his upward course, and will obtain a glimpse, however faint, of the Creator-Sovereign of the realms below. To Him he should direct the attention of his fellow-labourers still toiling up the heights, and thus encourage them once more to persevere.

He should not plume himself upon his own successes; but should employ them for the good of others. This is the high prerogative of every advocate of scientific truth.

"Truths that the learn'd pursue with eager thought
Are not important always as dear bought,
Proving at last, though told in pompous strains,
A childish waste of philosophic pains;
But truths, on which depends our main concern,
That 'tis our shame and misery not to learn,
Shine by the side of every path we tread
With such a lustre, he that runs may read.
'Tis true that, if to trifle life away
Down to the sunset of their latest day,
Then perish on futurity's wide shore
Like fleeting exhalations, found no more,
Were all that heaven required of human kind,
And all the plan their destiny design'd,
What none could reverence all might justly blame,
And man would breathe but for his Maker's shame.
But reason heard, and nature well perused,
At once the dreaming mind is disabused.
If all we find possessing earth, sea, air,
Reflect his attributes, who placed them there,
Fulfil the purpose, and appear design'd
Proofs of the wisdom of the all-seeing mind;
'Tis plain the creature, whom He chose to invest
With kingship and dominion o'er the rest,
Received his nobler nature, and was made
Fit for the power in which he stands array'd;
That first, or last, hereafter, if not here,
He, too, might make his author's wisdom clear,
Praise him on earth, or, obstinately dumb,
Suffer his justice in a world to come."

COWPER.

Plate I.

W West imp.

Corn.

CORN.

BY JAMES BUCKMAN, F.G.S., F.L.S., F.S.A., ETC., PROFESSOR OF GEOLOGY AND BOTANY IN THE ROYAL AGRICULTURAL COLLEGE.

THE notion entertained by the ancients, that corn was the gift of the beneficent goddess Ceres, may not improperly be held to express the fact that they knew little, if anything, of its natural origin, and that with them the need of reflection was obviated by attributing the possession of corn to a special divine interposition.

The honour paid by the Romans to the "bountiful goddess" may be gathered from the care which they evinced in depicting her form and attributes.

The representation of Ceres, on a tesselated pavement, discovered at Cirencester (*Corinium* of the Romans), gives no bad notion of the dignified treatment of which this kind of subject was susceptible, when, even with potsherds and bits of different coloured stones, the artist, aided as he must have been by profound veneration and deep religious feeling, produced a design of so much grandeur as to elicit from Mr. Westmacott, the Royal Academician, the observation: "These interesting specimens satisfy me, as an artist, beyond the shadow of a doubt, that such works were produced after examples of the very highest reach of art."*

But, however much the ancients may have venerated Ceres for her gift of wheat, &c., the care with which every natural object has been studied in our day has conduced to the conclusion that the so-called Cereals, in all the varieties employed by man for different purposes, were not *created* in the forms they now assume, but that they have been *derived* by cultivation from wild plants very different indeed from the civilized types with which we are at present acquainted under the collective name of Corn.

In England, wheat, rye, barley, and oats, are spoken of as corn; in the United States the *Zea Mays* (maize or Indian corn) enjoys that title solely; whilst different sorts of grain are mentioned under their specific names.

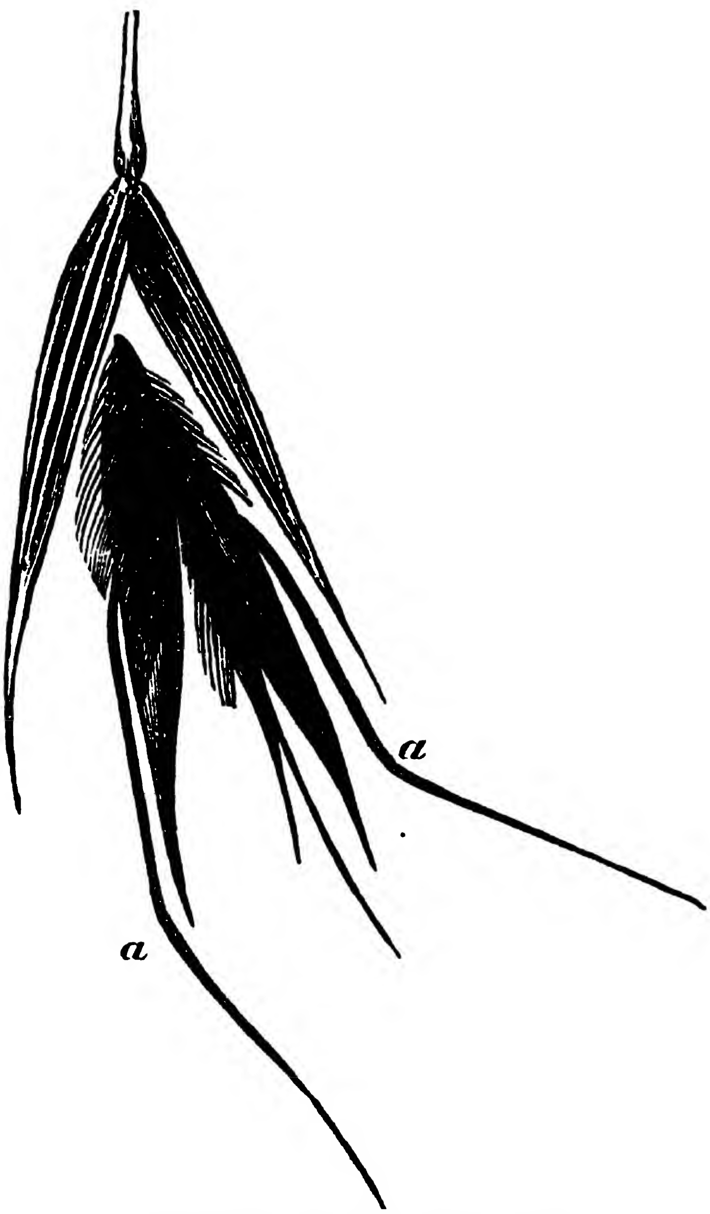
The scientific agriculturist, recognizing corn-plants as belonging to the natural order, *Graminaceæ* (in other words,

* This opinion was founded on a study of the figures of Ceres, Flora, and Pomona.

as being but an elevated grass), divides this order into two groups.

Firstly, CEREAL GRASSES (corn). Those yielding a seed large enough to be collected and stored as food for man and the inferior animals; and, Secondly, MEADOW AND PASTURE GRASSES, in which the whole plant is employed as pasturage, or fodder for cattle.

The seed-grain of the cereal grasses, then, forms the corn crop; and our own experiments, particularly with regard to the oat, show that our cultivated varieties, with their plump seeds, are derived from a wild oat, the seeds of which are entirely valueless—in fact, the whole plant is a weed, the mischievous nature of which is fully recognized by society when it speaks of a reformed profligate as having sown his wild oats.*



SPIKELET OF THE WILD OAT.
(*a a*, the Hairy Seeds, simulating a Fishing-Fly.)

The seeds of the wild oat are covered with stiff bristles (fig. 1) of a brown colour, and this, with the long bent awn, is in appearance so much like an insect, and the contortions caused by the untwisting of the awn as it touches the water so nearly imitates the behaviour of a struggling fly, that the country urchin employs it with success as a bait for trout, whilst the Waltonian, with his ingeniously constructed "artificial fly," may get little more than his exercise for his pains.

The wild oat is botanically known as *Avena fatua;* it grows from three to five feet in height as a weed in corn and pulse,

* We recollect once, whilst on a visit to a farmer in Worcestershire, having seen the weed-oat growing for the first time, and, though then on our way to church, we could not resist the temptation of plucking a specimen, which was at once consigned to our sabbatical botanical vasculum, namely, our hat; the contents of which were noticed by our friend, and elicited from him the serious (?) remark: "Ah, sir, what is the good of your going to church if you don't leave your wild oats behind you?"

in which, of course, it is a great pest, if only from the circumstance of its encumbering the ground, and so preventing the growth of the required crop.

About ten years since we collected some of the seeds of this weed (see engraving, fig. 1), and in the following spring commenced its cultivation in our experimental plots at the Royal Agricultural College, and so, year by year, we saved seeds; and in 1855 we were enabled to report the following changes:—

1st. A lighter-coloured fruit.

2nd. A less degree of hairiness, when compared with the fruits of the true *Avena fatua*.

3rd. A greenish-coloured, straight, and slight awn,* in place of the black rigid one, bent at right angles, and twisted at the lower part, which characterizes the wild plant.

4th. The fruits were much more plump, arising from a greater development of grain, than in the truly wild state.

5th. The ripe fruit separated from the floral envelope less readily than in *A. fatua*.

In 1856, seed with the characters just described was sown in a prepared bed, and the result was a large admixture of two forms or types of crop oats, one with the flowers all round the stem—the "potato oat" form of the farmers; and the other with the flowers all drooping to one side—"the so-called Tartarean oat." (See engraving, fig. 2.) Since then we have grown these sorts so derived, in the field, and with a gradual improvement in point of productiveness and weight per bushel, an item which no horse-keeper will fail to appreciate.

These experiments, then, have been of great interest, not only as proving that a cereal grass is derived from a wild or meadow grass; but that the remarks of old farmers, who, in some situations, objected to grow oats as a crop, "because they degenerated into the wild weed-oat," are founded on fact; *and it is a curious and interesting example of experience forestalling science.* This matter is further of great interest to the vegetable physiologist, as now we have, by experiment, obtained cultivated oats from wild ones; and since then we have watched the production of *wild* oats as a gradual degeneration from cultivated ones.

Wheat.—If one vegetable production more than another has come to be considered a direct gift to man, handed down to him in an unaltered state from the most remote periods, it is wheat; yet, when we consider the enormous number of varieties of this plant found in different parts of the world, and remember, too, that new sorts are introduced almost every year, we cannot help being struck with the capabilities of wheat to assume a variation, not only in external form, but also in differences in quality,

* The beard or bristle.

and with its power of adaptation to very variable conditions, such as those of climate, soil, and modes of cultivation.

Let us then start from the point of view afforded to us by an examination of the two more prominent English forms of wheat, which may be thus epitomised. *Triticum hybernum*—ear compact, smooth, or nearly so, beardless (smooth beardless wheats). *T. vulgare*—ear more or less hairy, with beard (awn) of greater or lesser length (hairy, bearded, or cone wheats). Of these there are so many varieties, that it would be almost impossible to enumerate them. Commencing then with these, we have to premise that, although their extreme differences are so great, yet they, after all, merge into each other; and we are justified in concluding that, as the sorts of wheat differ so much among themselves, the cultivated wheat-plant is derived from a wild grass. It may be remarked also, that nowhere is the wheat-plant found wild in any form at all resembling any cultivated variety. However, to quote the language of Mr. Bentham, in "Morton's Cyclopædia of Agriculture," article *Triticum*:—

"It has never been contended that their original types have become extinct, and various, therefore, have been the conjectures as to the transformations they may have successively undergone; and as no accidental returns towards primitive forms have been observed, we have, till lately, had but little to guide us in these vague surmises. Within the last few years, however, the experiments and observations of M. Esprit Fabre, of Agde, in the South of France, seem to prove a fact which had been more than once suggested, but almost always scouted, that our agricultural wheats are cultivated varieties of a set of grasses common in the South of Europe, which botanists have uniformly regarded as belonging to a different genus, named *Ægilops*. The principal character by which the latter genus had been distinguished, consisted in the greater fragility of the ear, and in the glumes (*i.e.* the chaff-scales) being generally terminated by three or four, and the pales by two or three points or awns (beards). But M. Fabre has shown how readily these characters become modified by cultivation; and wide as is the apparent difference between *Ægilops ovata* and common wheat, he has practically proved their botanical identity; for, from the seeds of the *Ægilops* first sown in 1838, carefully raised in a garden soil, and resown every year, from their produce he had, through successive transformations, by the eighth year (1846) obtained crops of real wheat as good as the generality of those cultivated in his neighbourhood."

A paper on this interesting subject, by M. Fabre himself, will be found in the "Journal of the Royal Agricultural Society of England," the following note upon which, from the pen of Professor Dunal, will not be devoid of interest:—

"The foregoing observations show that *Æ. ovata* (L.) is capable of being extremely modified under certain circumstances. Whilst its floral envelopes lose their width and some of their awns, and thus become like those of *Triticum*, their stems, leaves, and ears become more and more developed, and at length acquire all the characters of wheat. The necessary inference is, that some, if not all, cultivated *Tritica* are peculiar forms of *Ægilops*, and

ought to be regarded as races of this species. If this be admitted, it is easy to reconcile the accounts given of the origin of wheat. It has been said, both in ancient and in modern times, that wheat was wild in Babylonia, Persia, and Sicily. In all these countries *Ægilops* is common, and it is not surprising that some of its species may have accidentally acquired a wheat-like form, and have been afterwards improved and propagated by cultivation. Thus to M. Esprit Fabre is due the merit of having ascertained the true origin of cultivated wheat. Its origin had, it is true, been suspected and vaguely pointed out by several persons; but the honour of a discovery is really due, not to the authors of a surmise, but to him who has established the fact by observation, experiment, or reasoning, leaving no room for further doubt."

Now, it was the description of these experiments that determined us to obtain some of the seeds of the *Æ. ovata,* and submit them to cultivation. Our first sowing was in the year 1855, in the experimental garden of the Royal Agricultural College; but, probably owing to the cold climate of the Cotteswolds, upon which chain the College is situate, the annual changes were but slight; but in the warm summer of 1859 our plot of specimens had made great advances, which may be best explained by reference to our engraving.

Fig. 3 represents a spikelet of a type of *Ægilops ovata* such as we introduced into our garden.

Fig. 4. A spikelet of the same kind of grass modified by cultivation, 1859.

Fig. 5. An ear of bearded wheat.

Our crop of last year had not improved, but it is curious to note that this wet season produced in this grass all the ordinary blights on the stalks, leaves, and ears that usually belong to degenerate or badly grown wheat crops in this country, and more particularly those black dots of fungi on the stems and leaves called mildew.

Due reflection, coupled with the experiments to which reference has here been made, especially when combined with the tradition that the gift of wheat corn came from the East, would lead to the inference that a wild eastern grass was operated upon by the cultivator in very early times—indeed, at a period so remote as to be referred to the ancient gods; and the result was the production of a grain probably not so good as we grow in these days of advanced agriculture, but one in which the necessary changes were brought about from the large-seeded *Ægilops* to a still larger and so useful grain; and this transformation would of course be accelerated by the warm climate in which it was effected.

The subject of the production of new varieties of wheat is one of great national importance; for inasmuch as our wheat, like most other plants of cultivation, are but derivative forms or induced varieties, it follows that with long growth in any one district a particular sort is liable to become degenerate.

It may be said, indeed, that no crop is absolutely without a new variety. This may be selected and cultivated; and should the qualities for which it is chosen remain permanent, and be found valuable, its extension over the whole country is insured by means of advertisements, and by the reports of the large crops produced therefrom, and its value enhanced, securing a reward to the cultivator, to which he is justly entitled as a compensation for his toil. One of the more recent introductions of this kind is "Morton's red-strawed white wheat," the history of which is described in the "Cyclopædia of Agriculture," vol. ii. page 1131.

Another point of public interest is that, although our forefathers eat rye and barley bread, and that often of a very questionable dark colour and made from a very inferior grain, bread from these kinds of grain is now almost if not quite unknown in England. Not only do the masses now eat wheaten bread, but the drainage of our lands and better farming have greatly tended to the spread of the *finer* kinds of wheat all through the country.* All classes, then, are deeply interested in agricultural improvements, for not only do they tend to increase the quantity, but also to improve the quality, of human food.

We now turn to Rye; to illustrate the history of which for our present purpose we cannot do better than quote the following from the pen of Professor Lindley:—

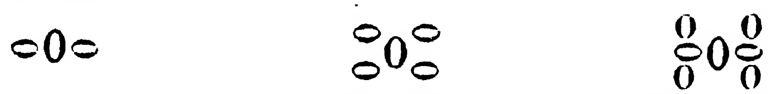
"*Secale cereale* (the common rye) is a cereal grass, distinguished from wheat by its narrow glumes, and constantly twin narrow florets, with a membranous abortion between them. Otherwise it is little different in structure, although the quality of its grain is so inferior. According to Karl Koch, it is found undoubtedly wild on the mountains of the Crimea, especially all around the village of Dishimil, on granite, at the elevation of from 5,000 to 6,000 feet. In such places its ears are not more than one to two and a half inches long. Its native country explains the reason why it is so much hardier than any variety of wheat, the southern origin of which is now ascertained."

Rye, more especially under bad farming, is subject to a malformation of the grain, by which it becomes elongated in the form of a black spur, which is seen projecting from the chaff-scales. This, which is known to the apothecary as *Secale cornutum*, is used in modern obstetric practice. As it was formerly ground up in the flour of the affected rye, the constantly partaking of so potent a drug in even small quantities is said to have produced the most fearful results, not only in man, but in the inferior animals who fed upon its grain or bread, such as decay and gangrene of the extremities, frightful convulsions,

* It is well known that in large towns, such as Liverpool, the working classes will have the very finest flour, whilst the middle classes mostly consume best seconds.—Ed.

and death. Happily, those improvements which enable us now to cultivate a less hardy grain (for such was wheat formerly, with greater reason than at present, held to be), have in our day freed man from those devastations which a bad year of rye entailed upon the human family in times gone by.

BARLEY, the last cereal on which we shall comment, is practically known under three forms according to the arrangement of the seeds, viz.—



TWO-ROWED. FOUR-ROWED. SIX-ROWED.

The two-rowed forms are those ordinarily cultivated in England; the six-rowed is more grown in Scotland, where it is known under the name of Bere. The four-rowed is, perhaps, only a variety of the six-rowed, as, in fact, may be the two-rowed—being, in one case, an abortion of a single seed in each spikelet; and in the other, the non-perfecting of two seeds; the whole spikelet having perfect seeds in the bere.

Barley belongs to the botanical genus *Hordeum*, but very various have been the opinions as to the wild species from which it has sprung. In all probability Professor Lindley's remark upon the *Hordeum distichum* is somewhat near the mark:—

"*H. distichum.*—This is the only kind of barley that has been found apparently wild. We have now before us specimens gathered in Mesopotamia, during Colonel Chesney's expedition to the Euphrates, with narrow ears, little more than an inch long, exclusive of the awn (beard), or four and a half inches, awn included; and others from the ruins of Persepolis with ears scarcely so large as starved rye. Both are straw-coloured, but that from Mesopotamia has the glumes much more hairy than the others."

The varieties of cereal barley are probably all derived from this type, or at least all the two-rowed ones; but still with us it is a matter of doubt whether the specimens just described are not after all derived from cultivation.

The *H. hexastichum*, six-rowed barley, or bere, in Scotland also called "big," of which there are several varieties, has been recommended from time to time to the English farmer. As Morton observes, "some enterprising farmer brings them out as novelties, while perhaps they have little else to recommend them."

"It is only lately (1848)," says the same authority, "that a considerable sale of black barley, at high prices, for seed, was effected by the advertisement of a story connected with it, which was singular enough to attract attention. The whole of the stock, it was stated, was raised from a seed taken from the crop of a goose shot on Lake Simcoe, in West Canada, whilst on its southern autumnal flight. But there was no need for the Canadian sportsman to have sent us the produce of this solitary

grain, for we have abundant stock of these varieties at home, as would long ago have been known to farmers in general, if either of them had deserved a more extended cultivation."

There is an old couplet which informs us, that—

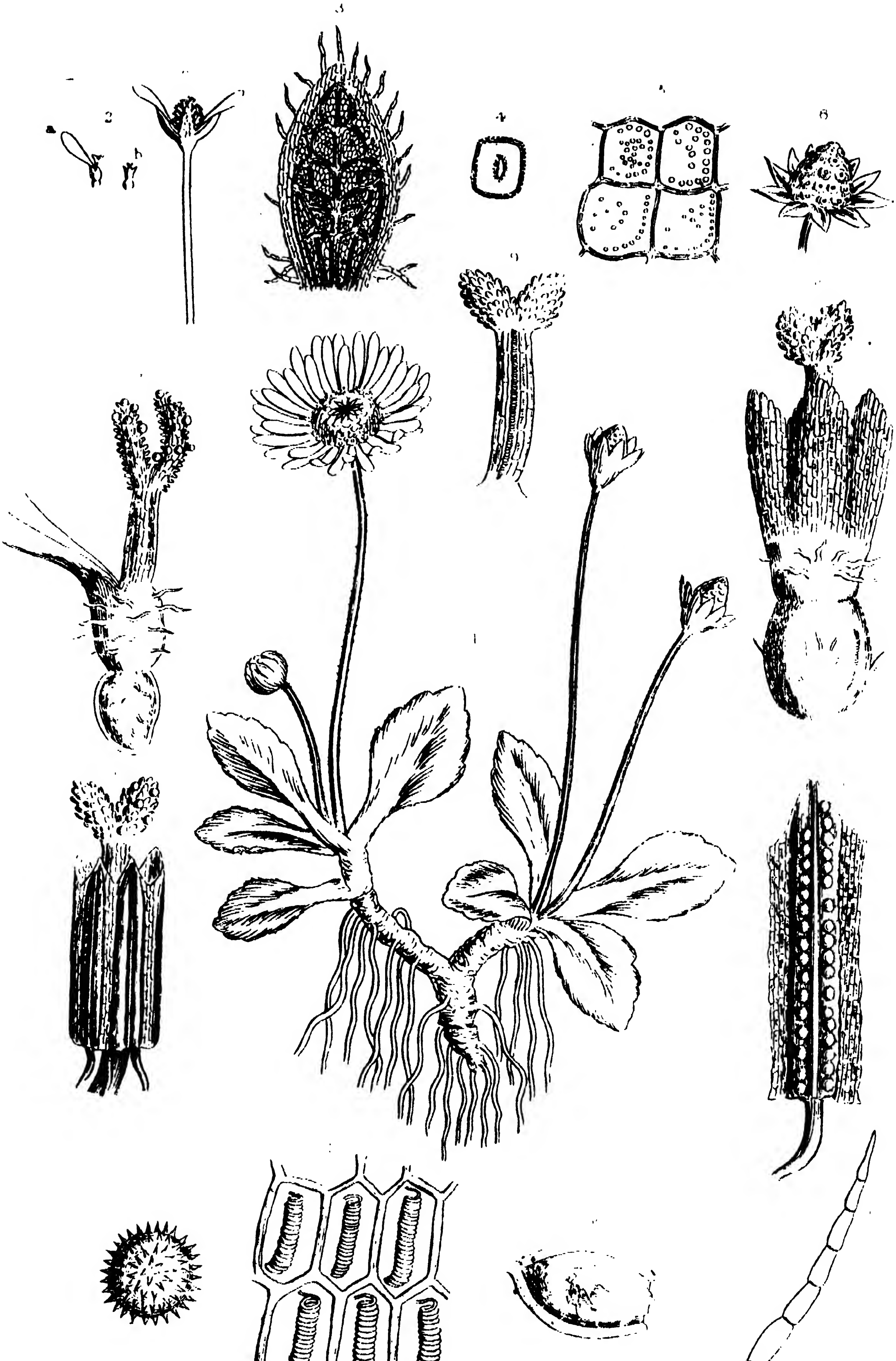
> "Turkey, carp, hops, pickerel, and beer,
> Came into England all in one year."

Now, as we incline to the belief that beer was known in England before turkey, carp, or hops, it is not improbable that this refers to the introduction of the *bere*, or big-barley, which latter is, in fact, still much grown in Scotland, being favoured by the climate; but the two-rowed variety not only grows better in England, but commands a higher price.

In bringing these notes on Corn to a conclusion, we would express the hope that our remarks have not been of too professional or technical a character for the readers of this Journal. To some extent they have been necessarily so, for it would otherwise have been impossible for us to draw attention to the all-important fact, that the corn-grasses are useful in consequence of the size and variety of the grain, and that these desiderata have only been acquired by careful cultivation. Reference might indeed be made to many more general truths in connection with the subject. It is our belief, on which we might have enlarged, that the production of more delicate and finer sorts of grains of every kind accompany a more extended civilization and a better class of farming; in fact, that grain is as susceptible of cultivation as is man himself, and that the one can no more remain at a standstill than the other. Nay, we may even carry the analogy still farther; for a degree of over-refinement in the plant is as productive of disease and degeneration as in the human being, so closely does the history of corn appear to be allied to that of our race.

Nor must it be supposed that the professional man is incapable of regarding the object of his studies solely in a utilitarian spirit—that he does not see in it something beyond mere drudgery. A "harvest home" is to us, at least, as joyful a spectacle as to the farmer whose grain is housed, and, we venture to say, in many instances, a more instructive one.

> "The harvest song we would repeat:
> 'Thou givest us the finest wheat;'
> 'The joy of harvest' we have known;
> The praise, O Lord! is all thine own.
>
> "Our tables spread, our garners stored;
> O! give us hearts to bless thee, Lord!
> Forbid it, Source of light and love,
> That hearts and lives should barren prove."



The Daisy

THE DAISY.

BY MRS. LANKESTER.

THERE are few plants which excite more general interest than the daisy. Growing extensively throughout the continent of Europe, its true home may, nevertheless, be said to be in the British islands. The very name speaks for itself; the "day's eye," as Chaucer, our old English poet, has it—

"The daisie, or els the eye of daie."

The daisy, botanically known as *Bellis perennis*, belongs to the natural order *Compositæ*, of which it may be taken as a type. Possibly, to those who know nothing of the general structure of this order, the daisy may present some difficulties, and it will, therefore, be preferable, in the first instance, to employ a larger flower of the same order for observation. The Sun-flower, the French Marigold, or the Ox-eye Daisy form good examples. First let us consider the flower-head, surrounded as it is with a bright green cup, or involucre, and having the appearance of a single flower, called by old writers a *compound flower*, with a *common calyx*. It is in fact, however, a number of florets, situated on a common head, or receptacle, the enlarged summit of the peduncle, or flower-stalk, is, as it were, expanded at the top, to admit of the introduction of the flowers. Thus, in a raceme, or long stalk of florets, they are situated at the sides of the flower-stalk. Were it possible to convert this into a composite flower, it would be done by pushing it down, as it were, until it spread out in every direction; the florets would then be fixed upon the expanded stalk now forming a receptacle. In the *Compositæ*, the receptacle is usually covered with chaffy scales, or hairs, which form interesting objects under the microscope. The involucre surrounds the receptacle, and consists of a number of bright green bracts, in some cases adhering together at the edges, in other cases distinct. Within this involucre are placed the florets, which are either all ligulate, that is, flat, linear, or oblong, forming only a short tube at the base, or the flowers are all tubular, or else the central flowers are all tubular and the outer ones all ligulate. In each floret the calyx is attached to the top of the ovary, and assumes the form of long feathery hairs, or *pappus*, as it is called, which, when the florets dry,

and fall off, still remain bleached almost white, and are familiar to us in the dandelions and thistles, where they are wafted away by the wind, like parachutes, bearing at their base the tiny fruit which is to perpetuate the plant. Inside the tube of the corolla we find the stamens, usually numbering five, sometimes four; they are adherent by their filaments to the corolla, and the anthers are united to each other in every case. This union of the anthers is one of the chief characters of the plants belonging to the order *Compositæ*.

The fruit of Compositous plants consists of a single little nut, placed immediately on the receptacle, below the pappus, to which it is attached, and this nut contains a single seed. The appearance of these fruits differs but slightly in the tubular and ligulate florets. In the disk, or central portion of the flower, the pappus which crowns the fruit is more perfect than in the ray, and frequently one of its hairs is elongated into a sort of stiff bristle.

The involucre has the power of opening when the flower expands, and of closing when the florets fall off, in order to inclose the young seed, and to protect it while ripening; it also opens and turns quite back as the fruits increase in size and become matured. This is particularly remarkable in the dandelion.

In order to facilitate the arrangement of this family of plants, it has been divided by botanists into three sub-orders.

First, *Cichoraceæ*, the Chicory or Lettuce sub-order or section, in which both the ray and the disk are composed of ligulate flowers alone, to the exclusion of all tubular ones. They are remarkable for their stems yielding a white, milky juice, which, when concentrated, has a soporific quality in some species. Some plants of this section are esculent, and are eaten as salads, such as the lettuce (*Lactuca sativa*).

The second section, or sub-order, is known by the name *Cynarocephalæ*, the Thistle-headed section. They have no ligulate florets, but consist entirely of tubular florets, generally very wide at the mouth. The common artichoke (*Cynara Scolymus*), as well as the various forms of thistles, belongs to this division.

The third section of Compositæ is the sub-order *Corymbiferæ*, the Chamomile section, with heads composed of both sorts of flowers, tubular and ligulate; the tubular ones are in the disk, the ligulate in the ray, hence they are called *radiate*. To this sub-order belong the asters, hence it is also called *Asteraceæ*. This is by far the largest section of Composite plants. To this division belong the Michaelmas Daisies, the Chamomile (*Anthemis nobilis*), Leopard's-bane (*Arnica montana*), the Dahlias of our gardens, the common Sunflower (*Helianthus annuus*), the Colts-

foot, Marigold, Groundsel, Ragwort, Elecampane, the Chrysanthemum, and our special favourite, the common Daisy, of which we will now proceed to speak.

From the foregoing remarks on the order *Compositæ* generally, the family relationship of our little friend will be pretty well established. Nowhere has the structure and general appearance of the daisy been described so pleasantly as in some letters on the elements of botany, by the celebrated philosopher and poet, Rousseau, but he does not appear to have thought of going further into the subject than would be suggested by merely external observation. We have at this day so many appliances at hand to assist our investigations, that if we are disposed to make use of them, we shall find in our little plant much that is most interesting, hitherto undescribed. Having determined to study the daisy in all its parts, no subject can be obtained with less difficulty. Throughout Great Britain, we find its tiny bright flowers springing up on every "lawn and grassy plot," by waysides, on mountain-slopes; and in almost every country in Europe may we find

> "These pearled Arcturi of the earth,
> The constellated flowers that never set."

In the extreme north of Europe, however, and in America, it is not common, and is there treasured as a garden flower. Though not exclusively a British plant, yet so closely is the daisy associated with the earliest recollections of every native of the British isles, that we can scarcely wonder that it is especially dear to the wanderer from home in distant lands, and that it brings back recollections of rural scenes such as cannot be met with elsewhere. There is an old Celtic belief that each new-born babe taken from earth became a spirit which scattered down on the land it had left some new kind of flower to cheer its bereaved parents; the tale is thus told:—"The virgins of Morven, to soothe the grief of Malvina, who had lost her infant son, sung to her—'We have seen, oh Malvina! we have seen the infant you regret, reclining on a light mist; it approached us, and shed on our fields a harvest of new flowers. Look, oh Malvina! among these flowers we distinguish one with a golden disk, surrounded by silver leaves; a sweet tinge of crimson adorns its delicate rays; waved by a gentle wind, we might call it a little infant playing in a green meadow; and the flower of thy bosom has given a new flower to the hills of Cromla.' Since that day the daughters of Morven have consecrated the daisy to infancy. It is called the flower of innocence,—the flower of the new-born."

Leaving the regions of fancy and poetry, which, however tempting and delightful if indulged in without some previous

knowledge of facts as they really are, frequently mislead and confuse the mind, we will commence our close examination of the daisy by digging up as large a root of the plant as we can find. The inhabitant of a town or city has it almost as much within his power to study this botanical specimen as one who lives in the wildest country district, for there are but few places so entirely denaturalised as not to afford some space devoted to a park, green, or open play-ground. On such a plot of ground we may almost surely find the omnipresent daisy. Those who have gardens and grass-plots or lawns, be they large or small, know but too well how inveterately these little plants disperse themselves over the otherwise smooth green surface, and disturb the equal growth of the velvet turf. Much as we delight to see the poet's flower on "waste of woodland rock or plain," we may without compunction remove it from our garden carpets, and turn it to scientific account.

First let us observe the root, or roots we should say, for they are perennial, and in digging up what appears to be but one daisy plant, we are sure to remove several others. There is an original root-stalk or rhizome, which sends into the earth numberless fibrous rootlets; from each original plant proceeds one or more creeping stems or offsets, which at a distance of about an inch or so produce buds or other little plants which in their turn send down fibres into the ground and propagate themselves by other offsets (pl. ii. fig. 1). This mode of propagation does not extend indefinitely as in some plants with creeping roots, such as the Potentilla, for we do not often find more than two or three offsets attached to each plant. It would appear as though after producing two or three new plants, the original connecting stem died away and left the young plants free.

Undoubtedly, the original plants are produced from the seeds, of which we shall presently speak; but the mode of propagation we have described is evidently very general in the daisy, for we seldom dig up a root without finding the attendant offsets attached to it.

The roots of the daisy have a slightly bitter astringent taste, and contain, in common with other plants of the same group, a portion of tannic acid. This principle has, however, never been separated, and it is doubtful whether the old recipe of "daisy-roots and cream" had more than a fancied efficacy.

Above the ground the daisy appears as almost interwoven with the materials forming the green carpet of our fields and pastures, so closely does it adapt itself to the circumstances in which it is found. In barren and uncultivated land it becomes a very dwarf, keeping its leaves very near the ground, and with its flower-stalk scarcely raised above the leaves. In rich mould and under favourable conditions its leaves assume a greater size,

the stalk rises several inches in height, and all its parts expand in proportion.

The leaves, of a bright grass green colour, appear above the ground at the end of the offsets, around which they are closely set; they are usually ten or twelve in number, shaped like a spatula or oval, with the end nearest the stem gradually narrowing off. The petiole or leaf-stalk can scarcely be said to exist. At all events, it appears more like the narrow continuation of the leaf than a petiole properly so called. These leaves are notched all round the broad end, which notches are tooth-shaped; they appear covered with hairs, which are depressed or lie on the surface of the leaf, and are more abundant on the lower side than the upper. The epidermis or cuticle exhibits a number of little openings, known as *stomates*, from the Greek *στόμα*, a mouth, which have the usual form and shape of those found in exogenous plants (pl. ii. fig. 4). These orifices allow a free communication between the external air and the internal tissues of the leaf; hence they have been called *breathing* pores. Some botanists have considered them as organs for the absorption of carbonic acid gas, which is the principal food of plants; but others, amongst them Schleiden, regard them solely as organs of exhalation, enabling the plant to throw off extraneous moisture. This view, which seems more probable than any other, is confirmed by the fact that stomates are entirely absent in succulent plants, and that in moist states of the atmosphere they are found closed, and in dry weather they remain open. There is but one rib up the centre of the leaf, the veins proceeding therefrom being hardly perceptible; but, by holding up the leaf to the light of a candle, they may be distinctly traced. Botanists describe the leaf of the daisy as obovate, spathulate, single-ribbed, crenate, dentate, which comprises in a few words what I have endeavoured thus to simplify and explain.

From the midst of the depressed whorl of leaves springs the simple flower-stalk, bearing at its summit the one flower-head. Each little plant or circlet of leaves may send up one, two, or three flower-stalks. These are covered with hairs, which become thicker and more dense towards the top. These hairs resemble those on the leaf, but are shorter (fig. 15). In their early stage the flower-stalks are solid; but as they grow they become hollow in the centre, and the cavity is especially evident near the top; this is formed by the growth of the tissue of which it is composed being more rapid externally than internally (fig. 2). Like the stems of all other exogenous plants, the stalk of the daisy is composed of cellular pith in the interior, which is removed as it becomes hollow; then some layers of woody fibre and bundles of spiral vessels, which are covered with an outer covering of

delicate cellular tissue or epidermis. At the summit, the flower-stalk expands into a receptacle, which is of a conical form, and at first is filled up internally with cellular tissue. When the flowers and fruit have been perfected and fallen off, we find the receptacle left, and that it has become hollow like the stalk. At first the receptacle presents the form of a small protuberance, but as it gets older it assumes more of a sugar-loaf appearance, which is very decided when the flowers and fruits have fallen from it.

Around the receptacle are placed the bracts in two rows, one behind the other, forming an involucre, or, as botanists call it where the bracts overlap, a *Phyllary*. These bracts number from twelve to fifteen. In order to examine them perfectly we must use the microscope. Under a quarter-inch object-glass, we observe the centre portion of the bract to be denser and of a deeper green than the outer edges, which are almost transparent (fig. 3). The cellular tissue (fig. 5) of which they are composed is elongated at the margins into delicate hairs; this condition of the edges of the bracts, produced by the absence of *chlorophyle* (the green colouring matter of the leaf), when very decided, is known by the term *scarious*. The surface of the bract is ramified with delicate veins running symmetrically on each side of the centre vein, and the intervals present stomates such as we have seen on the leaves.

The receptacle on which the flowers are placed is covered with little elevations which, when the flowers die and fall off, mark the places where they stood (fig. 6).

In common with the rest of the tribe *Asteraceæ*, the flowers are of two kinds, ligulate and tubular (fig. 2, *a*, *b*). The outer white bodies which appear so much like the petals of other flowers, and are so frequently mistaken for them, are in reality the ligulate flowers of the plant, each perfect in itself. It is almost impossible without a magnifying glass or microscope to comprehend the true nature of these pretty little objects, which are well worth careful examination. There is no apparent calyx, neither do we find any quantity of the downy pappus so abundant in some of the *Compositæ;* this organ seems to be represented by a few little hairs around the tube of the corolla in the daisy. The petal-like expansion is the monopetalous corolla of this ligulate flower (fig. 7). It is most frequently of a white colour, but in a large number of instances the tips of flowers will be found to be coloured pink. The pink colour sometimes covers the whole of the back of the flower.

The ligulate flower has no stamens or pollen-bearing organs, but has a single pistil which at the top divides into two branches forming stigmas (fig. 7). Under the microscope it is evident that the pollen grains produced by the tubular flowers, of

which we shall speak presently, have access to these stigmas, and so fructify the seed contained in the inferior fruit at their base. The whole body of the style is covered with delicate hairs. In the interior of the tissue of the style may be distinctly traced two or more spiral vessels, which are evidently continuous with those observed in the ribs of the leaves and in the flower-stalks.

Before speaking of the tubular flowers, we would draw attention to the fact that both the bracts and ligulate flowers move under the influence of the stimulus of light. In the evening these parts contract, and the whole head of flowers is "shut up," in order apparently to secure to the tubular flowers a night's repose. But under the light of the next morning's sun, the bracts and ligulate flowers spread themselves out to the fullest extent, so as to allow all access to the beneficent rays of the sun. This movement of the parts of plants under the influence of the sun's light is very general, and is even more marked in some other compositous plants than in the daisy. Every one is familiar with the fact of the sunflower turning its noble head of flowers towards the east at the rising of the sun, and closes its large bracts over its tubular flowers whilst nodding to it in the evening towards the west.

The yellow tubular flowers forming the centre portion of the daisy appear at first sight similar to the stamens of other plants, and to the casual observer would pass as such (fig. 8). Viewed under the microscope they are individually a perfect flower; each one of these little yellow bodies contains in itself all the organs of the perfect flower. The edges of the five yellow petals unite to form a monopetalous corolla around the five stamens which enclose the pistil. These stamens having very short filaments, are united together by their anthers (fig. 10), which are twice as long as the filaments, and form beautiful objects under the microscope. Usually, in examining the anthers of plants we find the pollen generally diffused in irregular masses in the interior of the valves or anther-cases, of which most plants have two; but in the case of the daisy, the pollen is found lying in two regular even rows in the cavity of the valve (fig. 11). At the time of shedding the pollen, the valve which encloses this row of bead-like bodies bursts by a longitudinal slit, and allows their escape on to the pistil in the centre or on to the pistil of the ligulate flowers surrounding them. Under the microscope the inner layers of the valve of the anther are found to be composed of fibro-cellular tissue (fig. 13).

Each pollen grain is round, and covered with minute spines, and forms a beautiful object under the microscope (fig. 12). The pistil which rises in the centre of the flower has an elongated style in which are discernible the spiral vessels that exist more or less in the whole tissue of the plant. The

stigma or top part of the pistil differs from that of the ligulate flowers in that it is not so deeply cleft, and each branch is more conical than those of the formerly described stigma (fig. 9). They are covered with little processes or projections, which seem provided for the entanglement of the pollen grains that fall on them.

At the base of both ligulate and tubular flowers we find the fruit which contains a single seed. The structure of the fruits of plants is a study of itself, for on careful examination the fruit is found to be a very complicated organ. The minute example before us has its various parts in as great perfection as the largest fruit with which we are familarly acquainted. There is the hardened *pericarp* (fig. 14), consisting of three membranes or layers, an external one called the *epicarp*, a middle one or *mesocarp*, and an inner one, the *endocarp*. In other fruits the middle layer being frequently of a fleshy or succulent nature, is also called the *sarcocarp*. Around the edge of the pericarp there is a sort of ridge or keel, which terminates at one end opposite to that where it was attached to the receptacle, and from which point the young seed or embryo sprouts forth. All over the surface of the fruit are minute depressed hairs, excepting on the keel, where there are no hairs to be seen. It does not appear that the single seed enclosed within this pericarp ever leaves its abode there; but, as it develops and grows, the walls of its habitation divide, and allow it to expand and grow beyond them.

Although this paper has been an attempt to enter as fully as possible into the microscopic structure and nature of this most interesting plant, there yet remains much to be done worthy the attention of the botanical student. The nature of the germination of the seed and the development of the earliest forms of the plant would supply materials for a series of experiments and researches.

It is well to remember that the forms and conditions of the daisy vary very much, according to the soil in which it grows and the circumstances under which it is found. In favourable soil the leaves attain a larger size, are of a brighter green, and the stalks of the flowers are much longer, than when we find the plant in poor and barren districts. As it approaches the sandy shores of the sea it becomes almost stunted, and produces small dark-coloured leaves and minute short-stalked flowers. In counting the number of flowers produced on one head under these various circumstances, we find that both the ligulate and tubular flowers vary from twenty to forty or fifty in number, the colour of the ligulate flowers is also very variable, from white tinged with pink to a deep pink scarcely showing any white whatever. In the cultivated garden daisy this is very evident; the tubular

flowers become almost, if not quite, obsolete, and their place is taken by ligulate flowers, which assume a deep pink colour.

In the variety known by the name of "hen and chickens," little flower-buds are formed in the axils of the bracts; sometimes as many as ten or twelve of these minute daisies surround the parent flower, thus suggesting its familiar name.

We can scarcely take leave of the little flower which has afforded us so much interest in the examination of its parts, without recurring to its poetical associations. The French name Marguerite has reference to the resemblance of its pearly bud to the rarer pearls of the ocean. Its Scotch name is *gowan*, and in Yorkshire it is recognized as peculiarly the flower of childhood, and is called *bairn wort*. In looking through old Gerarde's writings we find the daisy mentioned under the name of "*bruise wort*," as an unfailing remedy in "all kinds of paines and aches," besides curing fevers, inflammations of the liver, and "allo the inwarde parts."

We are not inclined to think with some writers that the botanical study and minute examination of this favourite flower in any manner detracts from its pleasant or poetical associations and simple beauty. The interest with which we have regarded each little starry flower, has increased tenfold since there has been revealed to us in that little circle multitudes of perfect flowers, each with its own organization, and in every leaf and stalk and tiny seed we have seen arranged and disposed tissues as wonderfully contrived and mechanisms as beautifully adapted to every condition of its life, as though it were the oldest cedar-tree or the largest oak of the forest.

CONTRIBUTIONS TO THE HISTORY OF THE ROTIFERA, OR WHEEL ANIMALCULES.*

BY PHILIP HENRY GOSSE, F.R.S.

I.

THE CROWN ANIMALCULE

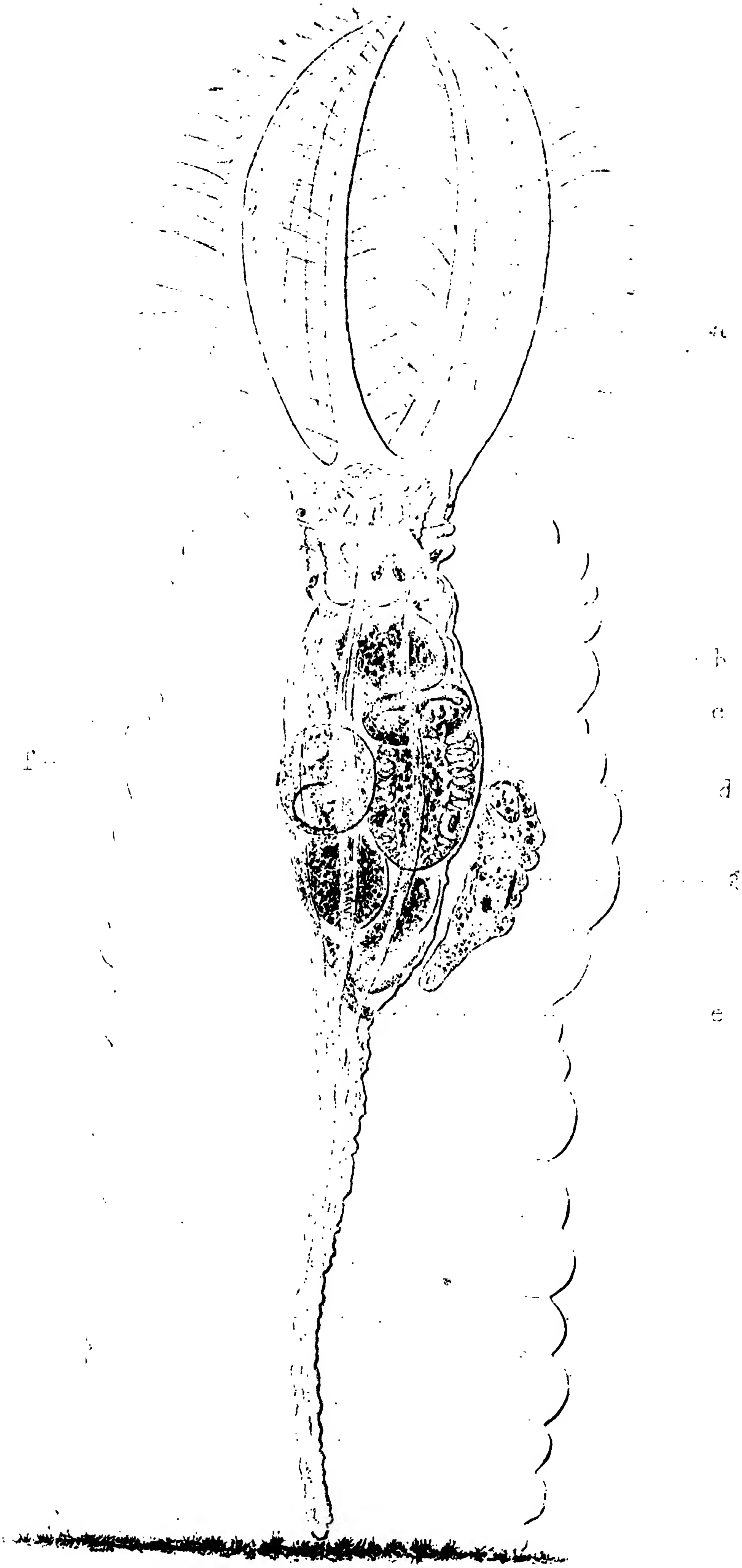
(*Stephanoceros Eichhornii*).

A LITTLE more than a dozen years ago, being then resident in London, I became a great frequenter of all the accessible collections of water in the vicinity of the metropolis. I had just purchased a microscope, and, looking with ignorant but interested curiosity at some drops of water from a neighbouring pool, was charmed with the varied forms and sprightly motions of the strange creatures that were disporting there. The result was the immediate determination to study and depict these—the creatures, namely, that were at that time included under a single group, and which had recently been opened up to the scientific world by Professor Ehrenberg, of Berlin, in his magnificent work, *Die Infusionsthierchen*. Since then it has been sadly pulled to pieces; like a block of granite, of which the constituent silex and feldspar and mica lie scattered in disintegrated granules, the great class *Infusoria*, so compact and firm as it appeared in the folio of the eminent Prussian microscopist, has dissolved under the storms of scientific controversy. One runs away with the *Rotatoria*, another with the *Desmideæ*, a third with the *Diatomaceæ*: the *Rhizopoda* get pickings; the *Annelida* put in a claim; and the remainder is so nibbled at, that we are fain to huddle away the few sheets of delicate engraving that are left in our hands, and hide them in a portfolio, for fear that Professor Agassiz should actually fulfil his threatening, and swallow up the whole.

Out of the great mass of strange forms thus brought under my notice, I soon selected the *Rotatoria*, or, as I prefer to call them, the ROTIFERA, as the objects of special attention and study; and for years thenceforth the examination, description,

* The papers of this series are chiefly intended for students somewhat advanced in science; but, so far as he has been able, the author has aimed so to simplify and arrange the matter as to convey intelligible information to such readers as have but little previous acquaintance with microscopical Natural History and Physiology.

Plate III.



The Crown Animalcule.

(Stephanoceros Eichhornii.)

and delineation of these tiny creatures became the absorbing occupation of my entire leisure. So elegant are their outlines, so brilliantly translucent their texture, so complex and yet so patent their organization, so curious their locomotive wheels, so unique their apparatus for mastication, so graceful, so vigorous, so fleet, and so marked with apparent intelligence their movements, so various their forms and types of structure, so readily attainable for study in almost every locality, and at all seasons of the year: that, as fact after fact and detail after detail of organization and habit revealed itself to me, I often wondered that scarcely any one seemed to know anything about them beyond what might be picked up from turning over the pages of Ehrenberg at the soirées of the Microscopical, or from the abridged translation of his letterpress and the copies of his plates, which Pritchard had published.

I have said that this line of study made me familiar with most of the accessible collections of water in and around London. It is one recommendation of the class ROTIFERA as an object of research, that the species are so easily procurable, even to a resident in great cities. A moderate walk sufficed to put me in possession of some or other of the hundred and twenty species that I know to be British, all of which, with the exception of a dozen or so, I have found immediately around London.

Some of these waters were private. My very first essay was on a pond in the grounds of Mr. Samuel Berger, at Clapton, where the white lily was sitting like a queen amidst her round green leaves, on the still surface. The large *Euchlanis dilatata* swimming at large, several kinds of *Salpina* grubbing among the *Nitella* leaves, the pretty *Mastigocerca carinata*, with its rat-tail and its singular unsymmetrical dorsal keel, and the curious *Actinurus Neptunius*, remarkable for its extreme development in length, with other more familiar kinds, rewarded my search here. From a reservoir in the grounds of Mr. Alfred Rosling, at Camberwell, were taken *Monocerca stylata*, a new species, *Furcularia gracilis*, *Philodina roseola*, remarkable for the rosy hue with which its transparent tissues are tinged, *Notommata petromyzon*, with its conspicuous ruby eye, and *N. parasita*, eating out the interior of the majestic spheres of *Volvox globator*. A tank in the garden of Mr. B. Edwards, at Shoreditch, which, though in the midst of brick and mortar, has been celebrated for the treasures which it has yielded to microscopists for more than a century, has yielded me, among many other things of interest, the fine *Rotifer macrurus*, *Philodina aculeata*, so singularly studded with curved prickles like those of a rose-bush, and a new species of the very interesting genus, *Callidina*. A small reservoir in my own garden, and even a mere earthenware pan, filled with water and allowed to stand in the garden for some

time, have been very productive of good things. In the latter I have taken the pretty little house-builder, *Melicerta ringens*, on the finely-cut leaves of the water-crowfoot, as well as the still more elegant *Floscularia ornata*, and the exquisite *Limnias ceratophylli;* and, among the sediment, the long-legged *Dinocharis pocillum*, the thick-necked *Notommata collaris*, the tiny but active *Diglena catellina*, munching the half-decayed leaves and dropping its large eggs here and there, and the singular creature which I have described under the name of *Diglena* (?) *biraphis*.

Wayside ponds I found productive. There is one near the turnpike-gate at Lower Clapton, which I often visited, and always with encouraging success. Among other tenants, it contained *Euchlanis luna*, that form with the shell so singularly hollowed in front as to give it the shape of a crescent; the jumping *Polyarthra platyptera*, with its twelve jointed spears; several species of *Brachionus*, and an interesting little new genus, which I have called *Pompholyx*. A pond at Tottenham-green, well stocked with the *Lemna polyrhiza*, or many-rooted duckweed, has given me some prizes. The first phial of water I carried home from this pool proved very turbid when examined, and appeared to contain no animal life; but, after standing a week or two, it became clear, and was found to be densely swarming with the fine *Brachionus pala*, and another species which I have named *B. angularis*. A broad pond in front of Forest School, at Walthamstow, has always been very rich in ROTIFERA. Thence I first obtained that large and brilliantly translucent species, *Asplanchna Brightwellii*, so singular in its structure and economy, which first made known to us the difference between the males and the females in this class of animals. Here, too, I found the elegant *Œcistes crystallinus* living in its pellucid tube affixed to the herbage; *Brachionus amphiceros*, interesting for the clearness with which it has allowed me to understand some difficult points of structure; the noble *B. dorcas*, a new species with very long anterior curving spines; and, swimming at large in the open water, the crystalline *Synchæta pectinata*, and the pretty little *Anuræœ*, incapable of rest, because destitute of a foot. Hampstead Heath has always been a favourite resort with microscopists. A pond where horses are watered, and another just behind the Castle inn, are very productive of species; but tiny hollows on the Heath itself, many of them scarcely a yard in diameter, filled with a red-brown water strongly impregnated with iron, and completely dried up in hot weather, are unusually rich. In these, among many vegetable forms of much beauty and interest, I took the little *Stephanops*, with its arched helmet; the *Conochilos volvox*, forming spherical groups united by the feet; and an interesting

new form, which I have named *Sacculus viridis.* Ponds at Barking, at Greenwich, at Battersea, and other localities, have also contributed their quota to my observations.

Even dykes and ditches are not to be despised. A small ditch in a field at Shacklewell yielded me the lovely, but rather sluggish, *Pterodina patina,* and the curious *Triarthra mystacina,* which leaps vivaciously hither and thither, by means of its three long bristles,—both somewhat rare species. Another ditch in Parson's field, Stoke Newington, through which a tiny stream trickles, produced *Noteus quadricornis,* a fine, and by no means common species. In a dyke at the Isle of Dogs, I obtained *Hydatina senta,* that transparent species which Ehrenberg selected as his standard in describing the organization of the class. Ditches at Stratford gave me *Chætonotus hystrix,* with *Scaridium longicaudum,* and *Notommata longiseta,* both remarkable for extraordinary longitude of limb; and an extremely curious form, very abnormal, as yet undescribed, but which I have called in MS. *Cochleare.* Then, again, in a dyke at Maidenhead—though this is rather beyond a walk from London—I found *Diglena grandis,* a very imposing species, highly predatory, and furnished with remarkable toothed jaws; and a new and fine species of *Salpina,—S. macracantha* (*MS.*). The reservoirs at Charing Cross, though not rich in species, have yielded me some of the free-swimming forms, as *Synchæta* and *Anuræa;* and among the conferva that grows along the stone-work of the margins, *Polyarthra* and *Furcularia forficula,* a rather good thing.

Collections of water of higher pretensions, such as the lakes in the public or private parks and pleasure-grounds, have not in general been more prolific in yield than these humbler pools and ditches. Yet these are the suitable places to search for those forms—in general of great beauty, and remarkable for their crystal clearness—which seldom or never rest, but are ever whirling with arrowy fleetness through the water. Such are the *Synchætæ,* which I have taken in some numbers in that fine piece of water known as the Black Sea, on Wandsworth Common, and the *Anuræœ,* mostly containing small, but very brilliant species, which are abundant in the lake in Kew Gardens. The Serpentine has yielded me, besides these, *Asplanchna priodonta;* and I have taken this, together with *Notommata clavulata,* a very fine thing, in the water in Regent's Park. From the lake in Richmond Park, I have obtained *Stephanops muticus, Philodina megalotrocha,* and some species of *Rattulus,* together with some of the stationary and tube-dwelling kinds, as *Floscularia* and *Melicerta,* and the fine predatory *Diglena forcipata.* Finally, the water in front of Kensington Palace produced me the greatest treasure of all,

the rare and noble *Stephanoceros Eichhornii.* It was not till after years of search that I discovered this; but, in April, 1850, it occurred in considerable numbers adhering to the minutely pectinate leaves of *Myriophyllum,* pieces of which were floating on the surface, and were washed on shore by the little wavelets that the breeze threw up.

The next year, at the same season, I again obtained it at the same spot, but in less abundance. A year or two afterwards I tried again; but the pond had been cleaned out, the *Myriophyllum* had been carefully scraped to the shore and carted away, and not a *Stephanoceros* have I been able to find there from that day forward. I learn, however, that it has been taken in a pool at Highgate, and my kind friend, Mr. W. P. Bodkin, who furnishes me with the information, has promised to be on the look-out, in order to supply me with specimens. To the history of this fine species I now address myself.

Stephanoceros and *Floscularia* are the most abnormal genera of the class Rotifera. They are very closely allied *inter se;* but differ importantly from all other forms. I associate them into a family, marked by the following characters.

FAMILY FLOSCULARIADÆ, OR THE FLOWER ANIMALCULES.

Animal free in infancy, permanently fixed in adult age, undergoing considerable change in form after birth, inhabiting a gelatinous tube which is excreted from the skin. Front produced into five lobes, beset with long ciliary setæ, or bristle-like filaments. Jaws seated far down in the abdominal cavity, not inclosed in a muscular bulb (*mastax*). Foot long, wrinkled transversely, neither telescopic nor retractile.

GENUS STEPHANOCEROS (Ehrenberg).

Frontal lobes long, slender, erect, convergent; ciliary setæ set around them in whorls. Jaws each of three teeth connected by a web.

There is but one well-established species, viz., *S. Eichhornii* (*Ehrenberg*). (See pl. iii.) This exquisitely elegant creature reaches the length of one-fifteenth of an inch, and is therefore distinctly visible to the unassisted eye. Ehrenberg can have seen only small specimens, as he gives one-third of a line as its ultimatum—one-thirty-sixth of an inch, and Leydig names half a line, or one-twenty-fourth of an inch; but I have seen several individuals of the dimensions I have named. The five lobes, which take the form of the petals of a flower in *Floscularia,* are here produced into long slender incurved arms, and the long setæ are arranged in verticils or whorls. They have not the length of those in *Floscularia,* but are still much longer

than Ehrenberg has figured them. I have traced them to a length equal to two-thirds of the greatest diameter of the body.* The points, however, run out to an extreme tenuity, and can only be perceived by the aid of delicate manipulation of the microscope. The five arms rise erect from the front, and converge to a rounded point after bulging outward, so as to present the figure of a tall crown or mitre (whence the generic name); but the points do not actually meet. It is rare to see a specimen with the arms spread, as Pritchard has figured (after Ehrenberg); I have once seen it in this condition; but I am persuaded that it is a mark of weakness or disease.

The front, at the base of the arms, forms a broad head, which is separated by a sort of neck from the body. This neck consists of two thickened collars, produced by deep annular infoldings of the skin. The body is irregularly cylindrical, or nearly so; but is generally swollen out in various parts by the full viscera, and the developing eggs. The dorsal side is the more swelling, and shows more distinctly the somewhat abrupt attenuation into the long and slender foot.† At its junction with the body, the foot is twice or thrice the diameter to which it diminishes at its lower extremity, where it is permanently attached to some foreign object, such as the leaf or stem of some submerged water-plant. Throughout its length this organ is much and irregularly wrinkled; it is capable of some degree of contraction, but it cannot be retracted within the body; it never shows any trace of those telescopic false joints which are so conspicuous in the *Philodinadæ*.

THE CASE.—The body is encased in a gelatinous envelope (pl. iii.), the general form of which is sub-cylindrical; but the outline is thrown into irregular transverse folds, apparently through sinking from its own weight. It is not a thin tube, as represented by Ehrenberg, with a roomy cavity, within which the animal lives, as *Melicerta* does; but is manifestly a thick and solid (if such a term is not a misnomer as applied to such a material) mass of gelatinous substance, with the exception of the space actually occupied by the body of the animal. From observations made upon the enveloping case, on occasions in which, for some reason or other, the animal voluntarily forsook it, it was apparent to me, that there was no organic connexion between the animal and its case, after the latter was once formed. The cavity left was nearly of the same form and dimensions as the body and foot, showing that it had been

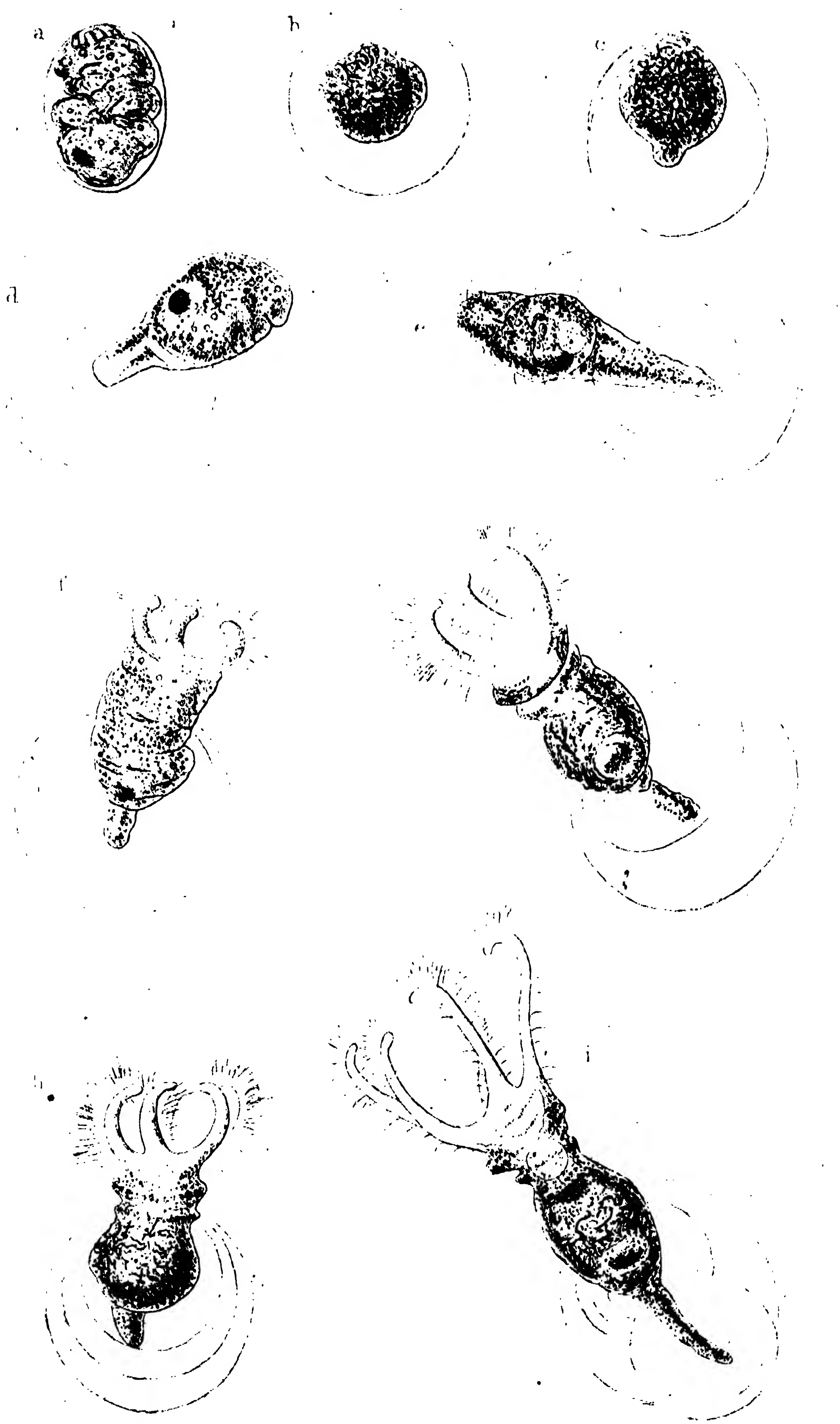
* Leydig makes them equal to the full diameter of the body.

† Leydig's figure (in Sieb. and Köll. Zeitschr., July, 1854) is, both in outline and in anatomical details, too diagram-like for life.

modelled upon these. During inhabitation the upper margin of the case is turned inwards; and when the animal suddenly and strongly contracts itself, the top of the case is somewhat drawn in after it. But this is not the result, as has been stated, of any adhesion of the margin to the animal, but simply that of the action of the water rushing into the vacuum suddenly produced by the downward retraction of the body, and carrying in with it the soft and flexible margin of the case.

The substance of which the case is composed is so delicately transparent that it is with some difficulty made apparent to the eye; indeed, only by its fine filmy outline. In old specimens, however, it acquires a brownish tinge, and much extraneous matter adheres to it. It is flexible, but not at all elastic; and apparently tough, without being viscid. Though, doubtless, a protection to the animal, yet, as with higher creatures, this advantage is not without its dangers. I once saw a *Stephanoceros* whose case had been accidentally bent down quite to a right angle, with many folds at the bend. The animal had no power to straighten it, but protruded, with its foot correspondingly bent. I have seen another, which, by some misadventure, had got one of its arms entangled in the substance of the margin of the case. It could not by all its efforts free the arm; and, after much apparent annoyance, during which this member evidently became diseased, the animal spontaneously forsook the case. Thus it remained, the foot (wrinkled up, indeed) projecting at a tangent, and the arm still fastened to the edge of the case by its ciliary setæ. Under these unnatural circumstances it soon died. While I am on these accidents, I may mention the example of another individual which voluntarily withdrew from its case. It was an operation of considerable labour and time; when the animal was clear of its tenement it slowly moved along by alternate elongations and contractions, but had no power of swimming. The foot presently wrinkled up into a distorted form, and the animal survived only a few hours. Doubtless, these forsakings are the expressions of the creature's uneasiness and an indication of disease. Such accidents should always be eagerly watched by the naturalist, as he frequently obtains an insight into structures and functions when these are modified by accident or disorder, such as no amount of patient investigation would have afforded him in the normal condition of his subject.

The summit of the case commonly reaches as far as the neck, or to the base of the arms of the animal when fully extended; and it is attached by its base, around the foot, to the support, as the leaves of *Myriophyllum* in my specimens. Thus the animal is completely enclosed to the height just named, and the only exit for the contents both of the ovary and the digestive



W. West, imp.

Crown Animalcule.

(Metamorphoses)

canal is at the top. In ejection the cloaca is much protruded and turned upwards; the fæces are discharged into the space between the body and the case-wall, and then gradually find their way upward and over the rim. The eggs are discharged into the same cavity, and there remain till they are hatched; the impressible substance of the gelatinous case yielding to make them temporary room; and the young when born struggle gradually upward and outward to liberty. But this I shall describe more in detail presently.

THE NUTRITIVE SYSTEM.—The internal organization of the *Stephanoceros* is complex, but the transparency of the tissues, at least when not occupied by the viscera, allows it to be well discerned, notwithstanding that the rays of light have to pass to the eye through various organs, the integuments, and the thick enveloping case.

The ciliated arms are carried commonly, as I have said, in an inarching form (plate iii. *a*), inclosing a considerable vaulted or somewhat ovate space. The setæ, or vibrating bristles, are arranged in whorls about fifteen or sixteen in number, but their closeness at the extreme point precludes the attainment of accuracy in counting. The whorls appear in perspective like pointed pencils, except on the arm which immediately fronts the eye, where they take the appearance of the beards of a feather. Those on the inside of the arms are seemingly much shorter than those on the outside, and form little brushes pointing upward.* Both arms and setæ are commonly held motionless; yet there is a manifest vortex in the inclosed area; for small *Infusoria* approaching are presently drawn in, and are driven about in the space. They can enter readily at all parts between the arms; but cannot get out, for if one approaches the arms from within it is seen instantly to be shot back towards the centre. At first I presumed this change of direction to be a spontaneous motion of the imprisoned animalcules, for they were active wayward Monads; but I perceived, after a while, a little inanimate atom have the same action; and, after some careful watching, I found that it was caused by the setæ; a minute, tremulous, and, as it were, spasmodic wave being seen to run along the nearest pencils at the instant. A slight jar of the stage or of the table will produce a similar wave along all the pencils simultaneously, as well as a momentary opening of the arm-crown. It is clear, then, that the setæ, crossing each other, serve as a living net, which admits the prey to enter without resistance, but if touched from within,

* Leydig thinks that the setæ are planted in a granular stratum external to the cuticle, from which they are detached in bundles when subjected to slight pressure.

vibrates in such a way as to jerk the touching body with considerable force towards the centre of the contained area.

The presence of animalcules, especially if active and highly coloured, such as those of the genus *Microglena* or *Euglena*,* in some abundance in the surrounding water, gives rise to an instructive and entertaining spectacle. One by one they quickly accumulate in the living trap, and a dozen or twenty may often be seen swimming about in it, till one after another becomes engulphed in the deep cut-like mouth-funnel below the arms. When once they arrive here they rarely escape; but the whole contents of the arm-trap are often lost at once by the sudden retraction of the animal into its case, when all the prey are left behind free to escape. Hence it appears that the victims are retained within the arms by the vortical current, produced, probably, by the cilia which line the mouth-funnel, whose action is persistent during the extension of the animal; but that at the instant of retraction the ciliary vibration ceases, the vortical current is intermitted, and when the arms are drawn back the Monads remain where they were, there being in that instant nothing to prevent their passing between the tips of the arms.

But when once the prey passes down below the area in question into the mouth-funnel, which is formed by very contractile walls, a slight constriction takes place in the neck, which has the effect of forcing the Monad down to the mouth of a capacious crop or *proventriculus* (plate iii. *b*), which lies all across the upper part of the body. Here a sort of swallowing motion is seen, and the prey passes with a gulp down into the cavity.

This crop is formed of thick granular walls, which run up in high processes on the dorsal and ventral sides to the bases of the arms. Within the ventral one of these processes, at its upper extremity, is inclosed a minute clear oval body, perhaps glandular. There is an irregular row of similar but smaller bodies running round the collar. An opaque, ill-defined, cloudy mass is seen on each side, evidently resident within the walls of the crop, in no wise produced or affected by its contents.†

At the lower part and towards the dorsal side of this crop is placed the masticatory apparatus (plate iii. *c*), which consists of the ordinary jaws, evidently imbedded in the wall of the crop, working freely in its cavity without an enclosing *mastax*.‡

* These forms are considered by many observers to be "protophytes," or lowly organized plants.

† Dr. Leydig says the crop is furnished with four long bristles having hooked extremities, which appear, by their resistance to *liquor potassæ*, to be chitinous. These I have not detected.

‡ I have elsewhere given the name of *mastax* to the conspicuous muscular bulb, which in most Rotifera contains the jaws, and which answers to the true mouth in insects, &c. (See my memoir "On the Manducatory Apparatus in the Rotifera," in *Phil. Trans.* for 1856.)

Ehrenberg's figures of the apparatus in this species seem more than usually incorrect; it is but fair to add, however, that he admits his observation to be susceptible of doubt; and I can give my own testimony to the exceeding difficulty of obtaining satisfaction as to the real structure of these minute organs. According to my judgment, formed on many careful examinations, and that in many specimens, each of the two *mallei* or upper jaws consists of three curved diverging fingers, whose extremities are united by an indented membrane like the foot of a water-fowl.*

The *incus*, or lower pair of jaws, consists of two very moveable and widely-separated *rami*, shaped somewhat like a quarter of a globe, but much flattened, and each furnished with a lengthened process, which unites with its fellow to form the hinge, without a *fulcrum*. The *uncus* is connected with the *ramus* by an elastic ligament, by which means the latter is stretched open vigorously, while the teeth of the *malleus* act on the prey imprisoned in the crop.

Let us now follow the engulphed, but yet vigorous and active prey. The crop we will suppose to be nearly full of *Monads*, as I have seen it to the number of a hundred or more; then we perceive how ample is its capacity, for it descends, with the contained prey, far below the level of the jaws, while the individual Monads on which the action of the jaws has been passing, often return among their fellows. During life, and seen in action, the *incus*, or lower pair of jaws, takes the form of a long oval box, partially open across the middle, or that of a pair of slippers without quarters, placed heel to heel, so as to cross each other at that part. The two *mallei* resemble hands continually engaged in tearing apart the two sides of the box, or the toes of the slippers, by which action the aperture is alternately opened and closed, or rather made to recede and approach. The living contents of the crop come successively, but by no means regularly, within reach of the jaws, and are dragged into

* These constitute the *uncus*, the lower part of which forms a knob, inclosed in a muscular mass, which seems to answer to the ordinary *manubrium*. For a full explanation of these terms, and the organs to which they are applied, I must refer to the memoir cited in the preceding note. I may say here that a general idea of the apparatus of the mouth, which is very complex in this class, may be formed by supposing a pair of gardener's shears, the two handles of which are soldered into one, and then bent down at a right angle to the blades. Then imagine two claw-hammers to be placed, one on each side, working in the blades of the shears, to which each hammer is tied by an elastic cord. Inclose the whole in a great rounded vessel, and fasten the parts to the interior by muscular bands, leaving an orifice with a tube over the blades, and another beneath and behind them, and you have a rough model of a Rotifera's mouth. The shears are the lower jaws (*incus*), of which the blades are the *rami*, and the united handles the *fulcrum*. The hammers are the upper jaws (*mallei*), the claw-head of which is called the *uncus*, and the handle the *manubrium*. The inclosing vessel represents the *mastax*.

the aperture between the slippers. Here the *mallei* press upon the prey (suppose it an *Euglena*), with rapid and forceful forward movements, until they gradually drive it through the aperture downward. It is now free from the jaws, but does not pass into the stomach, but comes up around the sides of the apparatus again into the upper area of the crop, and whirling around with its companions, is presently again laid hold of by the jaws. I have seen the process go on many times in quick succession, upon the same individual *Euglena*, which seemed to sustain little damage from the ordeal; still, I suppose it is bruised at every turn, and thus the digestive action is facilitated, which seems to commence in the crop. That the prey is not crushed or its form seriously altered, is clearly perceived from the fæces which I have seen composed of the various species of *Monads*, &c., dead, indeed, and mixed with turbid green matter, but scarcely at all changed in outline. Larger prey is sometimes devoured, which cannot be forced through the aperture of the *incus*; thus, I have seen in the crop at once two *Coluri* (minute but highly-organised ROTIFERA), each of which is larger than the whole dental apparatus. The contents of their shells appeared to be nearly dissolved.

Digestion is completed in a globose stomach (plate iii. *d*), opening out of the crop below the jaws. This is a viscus of considerable capacity, of which the walls are thickened by being lined with large turgid cells, of a yellowish-green hue, which probably secrete bile, and pour it into the stomach-cavity while digestion is proceeding, thus performing the functions of a *liver*. The colouring matter of the food itself, when vivid green animalcules have been swallowed, may be seen running in among the cells, and diffusing itself through the thickened walls, leaving a hue which is visible after the food has passed away from the tubular centre. The latter, the true stomach, is very dilatable and contractile. It is separated—by a constriction, or perhaps by a proper diaphragm, sometimes very distinctly visible, but not always—from a globose intestine of nearly equal capacity, which communicates by a rather long *rectum*, ordinarily wrinkled longitudinally, but capable of great expansion, with the *cloaca*, which, as I have said, is very protrusile.* It

* Dr. Arlidge (Pritchard's "Infusoria," Ed. 4, p. 419) appears to confound the *intestine* with the *rectum* in the entire class. I find, however, no difficulty in distinguishing, in almost all *Rotifera*, a true intestine, situate below the true digesting stomach, from a *rectum*, a canal into which the fœcal pellet is discharged, and in which it occasionally remains a few minutes before it is expelled through the *cloaca*. By this last term I mean the common orifice of the digestive and the reproductive organs. Dr. Leydig considers, and I have come to the same conclusion, from the same premises, myself, that the complete and rapid manner in which the cloacal orifice closes, after the extrusion of the fœcal pellet, indicates the existence of a sphincter muscle there.

is situated on the dorsal aspect, at the point where the swelling trunk abruptly narrows to the origin of the foot (plate iii. *e*).

Thus we have followed the alimentary function from its commencement to its termination, and have found that an organization, not a little elaborate and complex, is provided for this object.

The *Stephanoceros* is a voracious feeder. Ehrenberg saw large *Naviculæ* devoured by it, and in one individual a *Gonium pectorale*. He also saw that large infusory, *Stentor*, captured by it. Leydig witnessed the seizing of a great *Trachelium*, or various other *Infusoria*, and of the smaller *Rotifera*. I have myself seen the animal capture and devour scores of the *Infusoria* already named, in quick succession; and on one occasion observed one feeding on the young of *Floscularia digitata*, which were being hatched in considerable numbers in the same water.

The Reproductive Organs.—The reproductive organs occupy a very considerable portion of the bulk of the animal, and are sufficiently conspicuous at all times in the adult. Judging from analogy, I presume the *Stephanoceros* to be diœcious; that is, that the males and females are distinct individuals; but I have not had any opportunity of detecting the male, nor, so far as I am aware, has any other observer. It will probably prove to be very unlike the female, and to have much the same form as the rudimentary young, before the development of the arms; to be destitute of masticatory and digestive organs, and to have a conspicuous mass of opaque white matter within the interior. These characters mark the male sex in the Rotifera generally.*

A bent or rolled ovary (plate iii. *f*) occupies the greater part of the ventral region of the female, within which eggs may generally be seen in various stages of development. I have seen as many as seven eggs developing at one time in one individual. The undeveloped portion consists of a clear sac, containing a viscid granular jelly, often slightly turbid, in which are placed trans-

* Dr. Leydig mentions having found among *Stephanoceri* that he was keeping for observation, a young animal possessing somewhat of the vermiform figure, with a proboscis-like head, furnished with four projecting arms. The pair of eyes were discernible. Two considerable tubular appendages projected from the trunk-like process of the head, which were ciliated at their extremities; the cilia which at birth are set round the tip of the foot had disappeared, but were very evident in the abdomen, near the sac containing the atoms, which he considers urinary. *The jaws had the ordinary structure.* He mentions having also occasionally found another variety, which, together with the figure of the adult, had five arms, but was without any apparent sexual organs, while the foot and body were entirely occupied with fat globules. If either of these abnormal forms was the male, I conjecture it was the latter; for the presence of the well-formed jaws in the former seems to exclude that form from the masculine sex. Still it was a very curious variation.

parent, highly refractive globules, separated by a space about equal to their own diameter. These are the eggs in their primary rudimentary stage. The nucleus may generally be discerned in each as a dull spot, surrounded by a bright space. One of these eggs enlarges rapidly, and gradually becomes more and more granular, until it is almost wholly opaque. It is now become well defined, and assumes the size and yolk form proper to the mature egg; but this shape is not constant, for being as yet destitute of a shell, the soft and yielding yolk is forced into ever-changing forms by the varying pressure of the digestive and other viscera in their proper motions, and in those communicated to them by the inflexions and contractions and elongations of the body.

Meanwhile, what is termed segmentation of the yolk takes place. The turbid, semi-opaque mass may be seen to be divided across the middle into two masses, each of these into two more; and so on, until the whole has become a mulberry-like mass of small cells. When this stage is reached, the dull opacity disappears, and is replaced by translucency, in which, however, we begin to discern a complex array of organs and viscera. The egg now contains a living embryo, whose movements within its enveloping integument as well as those of some of its organs, as for example, its jaws and its vibratile cilia, can be discerned with ever increasing distinctness. These motions are rendered more distinct,—are more readily determined to be proper to the embryo, and not communicated from the viscera of the parent,—by the circumstance that the envelope has now hardened to a firm, elastic, perfectly transparent shell, accurately elliptical in outline, from the internal wall of which we see the embryo recede at various points, waywardly and irregularly. Besides the organs I have named, two crimson specks may be seen near one extremity, and an opaque, undefined mass at the other. Both of these are seen to more advantage by using the direct light of the sun reflected from the stage of the microscope with a dark background. Then the red specks come out perfectly defined, and of the richest vermilion hue, in the midst of the evanescent viscera, and the opaque posterior spot is seen to be quite white. The former are the eyes, which I shall speak of presently; the nature of the latter is not certain. Dr. Leydig supposes it to be an urinary concretion. It is very frequently seen in newly-hatched young Rotifera and in the males, I think, always (see plate iv. fig. *a*).

Development of the Embryo.—Dr. Mantell was the first to observe the development of the young in *Stephanoceros*; and in his "Thoughts on Animalcules" he has recorded some interesting results of his investigations. I have myself verified

his observations for the most part, and have also extended them. I shall speak of what I have seen, except where my experience differs from his.

Between the most matured egg in the ovary and the cloacal orifice, lies the *oviduct*, a membranous tube of great expansibility, but when not in use longitudinally corrugated so as to occupy a very slender space. When quite ready, the egg is rapidly forced through the *oviduct*, and in a moment escapes through the protruded *cloaca* into the interstice between the body of the parent and the wall of the enveloping case, the gelatinous substance of which yields to the pressure of the intruding egg. Here it lies close to the cloacal orifice for a short time, varying from half an hour to several hours, at the end of which the young is hatched (plate iii. *g*). In one instance which I watched from the discharge of the egg to the hatching, the escape from the shell took up several minutes, and appeared a laborious task, reminding me of a caterpillar becoming a chrysalis. In general the liberated young slowly presses its way upward between the parent and its case, till it emerges at the margin; but the one that I have just mentioned made its way through the side of the case near the top, *boring*, as it were, a passage through the gelatinous substance by means of its vibrating *cilia*; the force of the ciliary currents apparently abrading the soft jelly atom by atom. Dr. Mantell mentions one which penetrated through the *bottom* of the case, a process which occupied three hours before it obtained freedom.

As soon as the young is free from the parental case, it swims vigorously away. Its length is now about one-hundredth of an inch, or nearly one-sixth that of the adult (plate iii. *h*). Its form bears a rude resemblance to that of the parent, except that there is no trace of the coronal arms. The front is rounded, well set with strong vibratile cilia; the body is cylindrical, with many transverse corrugations, and a short thick foot is distinctly marked. The interior is occupied by a granular, often turbid, gelatinous flesh (*sarcode*), in which are placed many irregular bubbles (perhaps oil bubbles), a few large bladder-like organs (the rudiments of the future viscera), traces of the five muscular bands, which subsequently will move the arms, the jaws, well formed and situate near the middle of the body, two brilliant red eyes near the front, and the opaque white urinary mass near the site of the *cloaca*.

Having swum giddily about for a while,—longer or shorter, from a few minutes to half an hour,—it becomes stationary, finding a resting-place for its foot. In the live-box of the microscope it generally affixes itself to one of the glass surfaces. The specimen which I have before mentioned, which was hatched under my eye, swam for ten minutes, and then became

permanently attached to the upper glass of the box, so that it was vertical in its position, with the foot next to the eye—a favourable aspect for observing the development of the case. It presently began to dilate its body, and in about five minutes from its attachment, I perceived a distinct filmy ring around it, perfectly circular, whose diameter was about twice that of its body (plate iv. fig. *b*). The little animal now began to lean over to one side, and the ring soon had another segment additional, leaning in the same direction (fig. *c*). The case, for such it was, looked like two broad hoops of glass, each swollen in the middle and set one on the other, but not quite concentrically, at least to the eye of the observer. It was manifest that it was produced by an excretion from the body, owing its form and size to the animal's moving round on the foot as on a pivot.

Three hours after the hatching, the form of the young animal was elongated and maggot-like (in another instance the young was eight hours in attaining this stage, while others in the same period had the arms well formed and furnished) (fig. *f*); the case having the appearance just described. No trace of the arms had as yet appeared. Night intervened, and the next morning, eleven hours after birth, the arms were beautifully formed, and of considerable length (fig. *g*); the mouth-funnel was well marked, and the general shape had become characteristic: the case had increased in dimensions. At eighteen and twenty-four hours, I found the arms becoming more and more perfect, and at thirty-six hours after birth it was a perfect little *Stephanoceros* (fig. *i*), the outline of the body well developed, the principal viscera, the collars, the mouth-funnel, the muscular crop, the jaws—all distinct; the ciliary setæ were now arranged in whorls of pencils, and vibrated on a slight jar; the "urinary" concretion behind remained, apparently within the intestine, as a sort of meconium. Indistinct traces of the opacities of the crop began to be discernible. In the animal at this age, the arms, which have attained the full proportional length, are carried much more divergent than usual, and it occasionally expands the coronal circle nearly to the extent figured by Ehrenberg in the adult.*

* I have not in any case seen the first budding of the arms from the rounded front. But Mantell mentions (and refers to his figures, which are, however, very indistinct) a cluster of four or five sub-conical papillæ, which in a young thirty-hours' old were perceptible "*within the body*," and which he supposes to have been "the rudimentary rotatory organs," in other phrase, the arms. Then, again, he mentions, eighty hours after birth, the young as bearing "five mammillated projections, fringed with cilia on the upper margin, evidently the rudiments of the tentacula." These latter were doubtless what he supposes them to have been, but in the former instance I have some suspicion that he merely saw the points of the brachial muscular bands (see the fig. of young in plate iii.). He figures a yet further development at

Circulation and Respiration.—The performance of these functions in the Rotifera is involved in a good deal of obscurity, as is shown by the diversity of opinions that have been expressed on them by the most careful and judicious observers. I have but little light on the subject derived from the *Stephanoceros*, and must, therefore, consider it with reference to the entire class.*

In almost all Rotifera there is seen towards the hinder extremity of the body, usually in contact with the cloaca, a bladder, which is often of conspicuous size, sometimes occupying half the volume of the abdominal cavity, or even more, as in some of the *Brachioni*. It is known as the *contractile bladder*. Under the eye of the attentive observer it is seen gradually and insensibly to be distended, until it attains its full dimensions, when, from its extreme clearness, its well-defined form (which is generally globular, or nearly so), and from the fact that it pushes aside the surrounding viscera, it is very conspicuous. No trace of corpuscles, moveable or stationary, can be discerned by the most careful scrutiny in its contents; yet no one can look on it without feeling quite assured that it is distended by a fluid. Over the walls, in some species, may be discerned numerous filaments irregularly ramifying and meandering.

When the bladder has attained its utmost degree of distension it suddenly contracts on all sides, and wrinkles up to a barely perceptible point. The action does not occupy so much as a second; and as soon as it is accomplished the process of repletion goes on as gradually as before, and is followed by contraction in turn. The act of filling is called the *diastole*, the emptying the *systole*. The periods of contraction are generally uniform in the same individual, but sometimes they are very irregular.† The average interval may be perhaps set down at about fifteen seconds.

eighty-four hours, in which, however, they are not quite so advanced as mine in the earliest state in which I noticed them, at seven hours after birth (plate iv. *f*). The comparison of these data shows how extremely varying and uncertain are the periods of development in different individuals. They differ greatly even when the conditions appear exactly alike; as in specimens hatched in the same live-box, in the same water, from the same brood, and on the same day.

* I must beg my reader's indulgence if my descriptions appear somewhat obscure. I have laboured to be as simple as possible; but the subject itself is intricate and difficult, and cannot be understood without some personal acquaintance with the objects themselves, as viewed with the microscope. The future papers of this series, with their figures, will help to make the subject much more intelligible.

† They recur most rapidly, so far as my experience goes, in the *Monocercadæ;* thus in *Monocerca rattus* the contractions are about thirteen per minute, and in *Mastigocerca carinata* I have counted twenty-five in the minute.

In *Stephanoceros* there is a rather small but clear bladder (pl. iii.) placed behind the rectum, the filling of which I have repeatedly seen, but have never been able to catch clearly the contraction. Not that there is any doubt about the process, but I believe the animal invariably retracts its entire body at the moment of the *systole*, so that the process cannot be perceived in the confusion.

In connection with this curious organ there are others equally remarkable. Two bands are seen passing along longitudinally through the entire length of the trunk, one on each side, in most of the Rotifera.* They, for the most part, consist of threads, apparently tubular, hanging somewhat loosely, so as to form bends, which are invested with a thick corrugated envelope. Sometimes the tube forsakes the enveloping matter and passes straight along, while the coating forms a great bight. In some cases only one of these tubes can be seen on each side, but in others two, or even four, can be distinctly traced, loosely twisted together. The corrugated coating seems to consist largely of fatty matter, and may be intended for the protection of the delicate tubes. It is particularly copious in *Stephanoceros* (pl. iii.). These organs, which are called by pretty uniform agreement *respiratory tubes*, have never been satisfactorily traced to their anterior termination.†

Posteriorly, the extremities of the two tubes converge to the

* They are excellently well seen in *Asplanchna*, in *Notommata clavulata*, in *N. aurita*, in *Euchlanis*, and in *Brachionus*.

† Professor Huxley, describing them in *Lacinularia*, says, on this point, "Arrived at the level of the pharyngeal bulb [*mastax*] each vessel divides into three branches : one passes over the pharynx [*buccal funnel*] and in front of the pharyngeal bulb, *and unites with its fellow on the opposite side*, while the other two pass, one inwards and the other outwards, in the space between the two layers of the trochal disc, and then *terminate as cæca*. Besides these, there sometimes seemed to be another branch just below the pancreatic sacs." Possibly some of these apparent branchings may have been only threads of connective tissue, whose purpose is to fasten the tubes to the walls of the abdominal cavity. I have never been able to trace any coalescence of the anterior extremities of these organs in any species. In *Brachionus* I am quite satisfied that each vessel terminates (whether by an *open* or *closed* end I do not know) in the lining-membrane of the lorica close to the lateral frontal spine ; for the vigorous retractations of the moveable head-mass do not at all affect the relative positions of these vessels, nor throw them into curves. In *Euchlanis*, on the other hand, they terminate in the head-mass itself, and are not attached to the lorica. In *Stephanoceros* I have sometimes thought that there was such a connexion of the vessels as Mr. Huxley speaks of ; for the curious little tremulous bags (which I shall presently describe) are found chiefly in the region of the neck, arranged around the second collar, but I have not been able to detect their attachment. I have seen *five* at once on this level, which seems inexplicable on the supposition of the supporting vessels passing only longitudinally on each side. I saw another tag on the dorsal side, a little below this level, and (in another individual) two at one level near the bottom of the stomach. (Pl. iii.)

surface of the contractile bladder, and seem to me to ramify over it, entering it by many mouths. One of those accidents which we can never command or control, but which are often highly instructive, gave me a little insight into the nature of the termination of these vessels. Examining a specimen of *Monocerca porcellus* which I had killed by means of the compressorium, the sudden and strong pressure severed the tortuous respiratory tubes and forced them out of the shell (*lorica*) hanging from the head-mass. They now appeared like crumpled cords, covered with close transverse lines, probably the effect of corrugation in contracting; and from their posterior regions *many short lateral branches were given off, the extremities of which had evidently been forcibly torn from their attachments.* I have never seen any tendency to a trumpet-like expansion of the posterior extremities of the tubes, at their entrance into the bladder, as Leydig implies, nor can I call this latter organ "a dilated state of the united ends of the two respiratory canals," even in *Stephanoceros.* Small as it is in this species it appears to be of the normal structure.

The most remarkable part of the whole apparatus, however, is the series of minute tremulous bodies which are attached to the respiratory tubes, much like the tags of rolled paper which are tied on to the pendent tail-string of a boy's kite. In all the larger ROTIFERA the watchful eye catches, from time to time, a tiny object that has a wavering motion, like the flickering of a flame. Often it cannot be detected at all; often one only, or two such objects are caught; but in favourable conditions we may generally discern four on each side (in *Asplanchna Brightwellii* more than a dozen) attached to each tube.

Ehrenberg was more happy in the function he ascribed to these minute organs, than in his physiological nomenclature generally. He says, "Their function is respiratory, and they are analogous to gills: the tremulous motion observable is that of the *laminæ* composing them." Here, however, he was misled by the deficiency of his instrument, and spoke too confidently from mere conjecture. Their structure is not laminated. They are evidently little ovate, or pear-shaped vessels, seated by a short foot-stalk on the respiratory tube and projecting into the body cavity so freely, that they are swayed hither and thither by every movement of the fluid with which the body is filled. The flickering motion is seen to be produced by a single cilium, which occupies the interior of the little tag, running through its centre lengthwise, attached near its free end, and pointing downward to its base. A rapid waving movement is communicated to the cilium, which is at pleasure intermitted; and so it is quite common to see only one or two tags flickering at

once. Somtimes the tags appear triangular or broadly pear-shaped, sometimes nearly cylindrical, or slightly elliptical.*

Such are the forms of the organs, so far as they can be determined. It remains to investigate the function and the *modus operandi*.

The first question is, what becomes of the contents of the contractile bladder at the systole? It is exceedingly difficult to trace the outflow of the fluid, and I have watched often and anxiously with the utmost care to detect this, in vain. Is it discharged into the cloaca, and so effused from the body? or is it poured into the respiratory tubes, and so passed into the system? Analogy would lead one to conclude the former to be the case; but, as I say, it is very difficult to see it. On one occasion, however, I saw this decisively. Carefully watching a specimen of *Notommata clavulata*, having previously mingled carmine with the water, I observed that the region of the rectum situate between the bladder and the cloacal orifice was distinctly puffed out at the instant of the contraction, and now and then I discerned, quite indubitably, that the minuter atoms of floating carmine were shot away by a discharged *jet d'eau*. Thus the excretory office of the bladder was decisively proved.

Whence, then, comes the fluid that is so discharged? Some have supposed that it is derived by direct and immediate percolation from without, through the cloaca.† Others believe that the sac is filled from the tortuous vessels. Dr. Leydig adopts this hypothesis. He believes that the water enters the general cavity from without, either by endosmose,‡ or by minute orifices hitherto undetected, and then mingles with the products of digestion, absorbed through the thin walls of

* These have been described as of two kinds. I find, however, that the variation depends on the aspect in which they are viewed. In a specimen of *Brachionus dorcas* I casually obtained a very satisfactory view of one of the tags in the line of its long axis, when it was manifestly a flattened body. The triangular form is, then, that of the flat—the sub-cylindrical that of the edge. Cohn, correcting the error of Leydig, has also given this explanation.

† Mr. Dalrymple suggests that the bladder draws in water, and expels it again, by the cloacal orifice, and that it is by bringing the blood, by means of the ciliary movements of the tags, into immediate contact (the delicate membranous wall of the sac intervening) with the air of the water, that aëration or respiration is performed. M. Perty adopts this explanation. Dr. Cohn believes that he proved the existence of this incoming current, as well as of the outgoing one, in *Brachionus militaris*, a species peculiarly favourable for observation, on account of the enormous development of the bladder. On mingling colouring matter with the water, Cohn says he witnessed an inward current during each dilatation, and an outward one on each act of contraction, alternately.

‡ *Endosmose* is that law by which a thin fluid passes through a membrane to mingle with a denser fluid inclosed in it. (It is fully described in the paper on "The Lowest Forms of Life."—Ed.)

the intestine, to form the "chylaqueous fluid" of Dr. Williams, —the analogue of blood in the superior races. The effete water is then directed through the tags by their open ends, the vibrations of the inclosed cilium imparting the inward current to it, and so into the bladder. I quite believe this to be the true state of things; and therefore, that the respiratory tubes represent the kidneys, and that the bladder is a true urinary bladder. Thus in INSECTS, with which class I consider the ROTIFERA most closely allied, the kidneys exist in the form of long, often tortuous tubes, generally from four to eight in number, and often those of each side twisted loosely together, in which uric acid has actually been detected; while in some, as the water-beetles (*Dyticidæ*), there is a voluminous urinary bladder.

If this explanation be according to fact, it follows that the respiratory and urinary functions are in the closest relation with each other.

THE NERVOUS SYSTEM.—The nervous matter in this class exists in a remarkably concentrated and conspicuous form, constituting a cerebral mass, which, for its proportionate volume, may compare with the brain of the highest VERTEBRATA. One is amazed to find such an organ in the lowest type of the ARTICULATA, so compact, so well-defined, so large; and it is not without considerable hesitancy that we are induced to admit its right to a cerebral character. Yet there can be no reasonable doubt, that such it is. Its position in the anterior region of the animal, and usually with a dorsal aspect; its rounded outline, and compact figure; its greyish, granular texture; and, in particular, the connection with it of the eye, which is invariably seated like a wart upon it,—reveal its true character, which, so far as I know, has not been questioned by any observer.

Leydig does not recognize the brain in *Stephanoceros*;* yet I find it clear and indubitable, though small. (Pl. iii.) It is placed on the dorsal side, just beneath the second collar, behind the upper part of the crop, and immediately beneath the

* I do not mean that he has not described and figured the organ, but he does not recognize its function or homology. Under the title of "Special Organ," he has these words: "Immediately over the crop is found a structure, the value of which is unknown to me. It is a group of vesicles, clear as water, which together form a body ·024 line in diameter, which opens by a short but evident passage in the cuticle." This is certainly the brain. Its position, its conformity of structure with the brain in other ROTIFERA, and the seating of the red eye-point on its rotundity, which I have distinctly seen, leave no doubt on the point. The orifice he alludes to is paralleled by what I believe to be antennal orifices in *Asplanchna*, and by an actual antenna in *Notommata clavulata*, to which muscular and nervous threads go direct from the brain.

integument, which, in some specimens, makes a very distinct bulging or tumour to receive it. Indeed, the form of the organ, which is vertically pear-shaped or ovate, is always to be traced in the exterior outline. Its substance is delicately granular. I have not been able to trace any nerve-fibres given off from it; but around the frontal expansion, just at the base of the arms, goes a band of substance (pl. iii.), evidently very different from the muscular bands, and apparently not vascular, which is connected by branches with another broader band, that passes round at the upper collar; descending branches and threads go from this also, and appear to pass to the walls of the mouth-funnel and crop. These are probably nerves. I suspect there is a nerve-thread, which passes centrally through the entire length of each arm.*

On the upper part of the brain, and on its anterior (or ventral) surface, looking forward across the crop, is seated a minute but well-defined eye. By transmitted light it can scarcely be detected at all, and hence, probably, it has been usual to consider the organ as obliterated in infancy; but, under the rays of the sun, thrown on the object by means of a condenser, and reflected from it, the eye comes out sharp, distinct, and beautifully red, as if a globule of rich opaque vermilion had been placed among the clear pellucid flesh. I have no difficulty in finding it in adult specimens, by this mode of examination.

In the newly-hatched young there are *two* eye-spots. How these become changed into the single eye of the adult I do not know; I suspect by coalescence. I have, on more than one occasion, seen *three* eye-spots in a mature egg, of which one was minute, and under the others. I should have thought it an accidental monstrosity, but that I remarked it in two eggs. They were not prismatic spots, nor oil-bubbles, but globular specks, of opaque red, seen under sunlight.†

The Muscular System.—In its more prominent features, this is very distinct. A muscular band runs round the frontal disk, at the base of the arms, forming a low arch, or bow, in the swell of each arm-base. To this annular band are attached strong longitudinal bands, which run through the whole length of the body. These are associated in pairs, running side by side—five pairs in all,—each pair exactly corresponding to an arm in direction. Each pair begins to separate at the level of the upper collar; and, having been connected by a short

* See *infra*.

† There is no doubt at all that the crimson specks found on the brain in most Rotifera are real eyes. The *lens*, in some species, is distinctly discernible.

transverse band immediately after the commencement of the divarication, the individual muscle-bands join the annular band at remote points. Such seems the usual order, but it is not invariable; for in some specimens I have seen muscle-bands which seem to run down direct from the intervals of the arms, without uniting to form pairs. The longitudinal muscles pass through the foot, having, as I suspect, an insertion into the walls of the body near the origin of this member, by whose aid the foot can be thrown into strongly-marked transverse corrugations.

Besides the annular band mentioned, there is another which passes round the neck, unconnected with the longitudinal series, at the level of the first collar; and there are threads which are contractile, and therefore, I presume, muscular, which pass from side to side of the walls and processes of the mouth-funnel. I have not been able to trace any of the special muscles of the trunk, though doubtless such exist.

Diseases.—I have already alluded to the tendency of the *Stephanoceros* to disease. One curious malady it seems rather subject to. The foot attenuates, and soon appears to be dissolving in some parts. When the dissolution has extended through its thickness, the animal draws up the proximal portion that remains, and thus, having now no connexion with the gelatinous case, becomes free. The arms now become feeble, and can no longer maintain their beautiful mitre-like form, but expand widely; parts of the viscera also appear dissolving, and sometimes there is a protrusion of the intestines. Yet strong contractions of the body and vigorous working of the jaws still go on, twelve, eighteen, or even more hours after these symptoms have manifested themselves. At length the arms decay at the base, and become separate, when one part of each swells out into a large bladder, doubtless by the expansion of the gases formed in decomposition, and reveals an item of structure which is not discernible in health. Through the centre of the swollen part runs longitudinally a cord, which, from its granular appearance, and its resemblance to the bands that pass round the head, I judge to be nervous matter. The arms seem peculiarly liable to disorder. Often, towards the extremity of one, minute bubbles appear in the substance; these increase in number, and take the appearance of a congeries of minute black specks; soon that part of the arm sloughs off, and thus it is common to see a *Stephanoceros* with one or more arms reduced to stumps.

The arms are capable of being constricted, bent nearly at an angle, or drawn up, with close-set wrinkles, into a very short space. This last process sometimes occurs with one arm alone;

sometimes with all at once. One in my possession, from a perfect condition, so shortened all the arms (not, however, while under my eye), that they were reduced to the merest rudiments or tubercles, retaining a few of the pencils of setæ; and though these subsequently lengthened a very little, they did not become normal again.

Of an individual which I had found in health, the foot, the next day, separated itself from its attachment by the sloughing of a portion, leaving a ragged edge. The body did not withdraw from the case. The foot went on to dissolve away upwards, in a very ragged form: about the third day the arms became shrunken, flat, and distorted. The setæ were now seen to be of great length; they vibrated still when jarred, and now and then spontaneously. Under these circumstances the nature of the vibration was far more discernible than in health. I could now distinctly see that each seta bent laterally, and then straightened itself like a whip smacked; the flexion was performed suddenly, the extension gradually. The flexion appeared to be from south to west.*

The animal is not difficult to keep alive in jars of fresh water, exposed to the light, but guarded, of course, from the hottest rays of the sun. The water-plants on which it lives attached are essential; but these need not be rooted. Fragments of *Myriophyllum, Ceratophyllum, Nitella Potamogeton,* &c., may be detached, and will continue to live and grow while submerged. I have kept *Stephanoceros* for five or six weeks.

I do not know any other localities in the British Isles for the species than those which I have mentioned. But it is widely spread on the continent. Eichhorn found it at Dantzig, exactly a century ago, and figured it in 1775. Ehrenberg rediscovered it near Berlin in 1831, and afterwards saw it on several occasions. Weisse met with it once at St. Petersburg. Perty's *Stephanoceros glacialis,* found by him in Switzerland (in the Todtensee, on the Grimselhöhe), was probably only a deformed and diseased specimen of *S. Eichhornii.*

Such is the history, so far as I have unravelled it, of the largest, the rarest, and the most elegant species of the class Rotifera. An exquisite form it is, and one whose structure

* I use this mode of indicating circular motion, because it is precise: we have only to suppose the plane of the circle to be horizontal, and no mistake can possibly be made. The ordinary phrase, "from left to right," or *vice versâ,* is indefinite and ambiguous, because "right" and "left" are *opposite* points of a circle, and motion from one to the other may be in opposite directions. If to describe the sun's apparent motion as "from left to right" is intelligible with us, it is only because a portion of the circle is beneath the horizon. At the poles it would be quite ambiguous.

and habits will, I have no doubt, abundantly repay investigation by careful observers with good instruments, as there are many points in its economy on which we need further light.

EXPLANATION OF THE ILLUSTRATIONS.

PLATE III. represents an adult female *Stephanoceros Eichhornii*, magnified one hundred diameters. A young one, just hatched, is seen within the parental case, working its way upward to liberty.

PLATE IV.—Metamorphosis and development of the same. Fig. *a*, The egg just ready for hatching : *b*, The young, fifteen minutes after birth, permanently attached, with the first elements of the case deposited : *c*, The same, twenty-five minutes old, with a new segment to the case : *d*, Another individual, four hours old : *e*, One, three hours old. The development in these two is at about the same point, but that of the case in *e*, though the younger, is rather the more advanced : *f*, *g*, *h*, Intermediate conditions, from six to twelve hours old : *i*, The adult form perfectly developed, at thirty-six hours after birth. Figs. *b*, *c*, *e*, *g*, and *i*, represent the same individual. In each figure, the foot of the animal must be understood to be adherent to the *farther* surface of a plate of glass, and the case to be attached around it, so that both animal and case project *from the eye.*

For fuller information on all that has been published concerning this species, the reader is referred to Ehrenberg's Memoir, in the "Berlin Transactions" for 1831, and his "Infusionsthierchen;" to Dr. Mantell's "Thoughts on Animalcules," and to Dr. Franz Leydig's admirable Memoir on the ROTIFERA, in Siebold and Kölliker's "Zeitschrift," for July, 1854. The new edition of Pritchard's "Infusória" (1861) contains a valuable summary of the researches of the continental *savans* on the whole class, including, of course, the present species.

THE LOWEST FORMS OF LIFE.

VEGETABLE LIFE—THE "PROTOPHYTA," OR "FIRST PLANTS."

BY THE EDITOR.

THOSE who have never witnessed the beauties of the microscopical world can form no conception of the astonishment and delight afforded by the first glance into the magic tube.

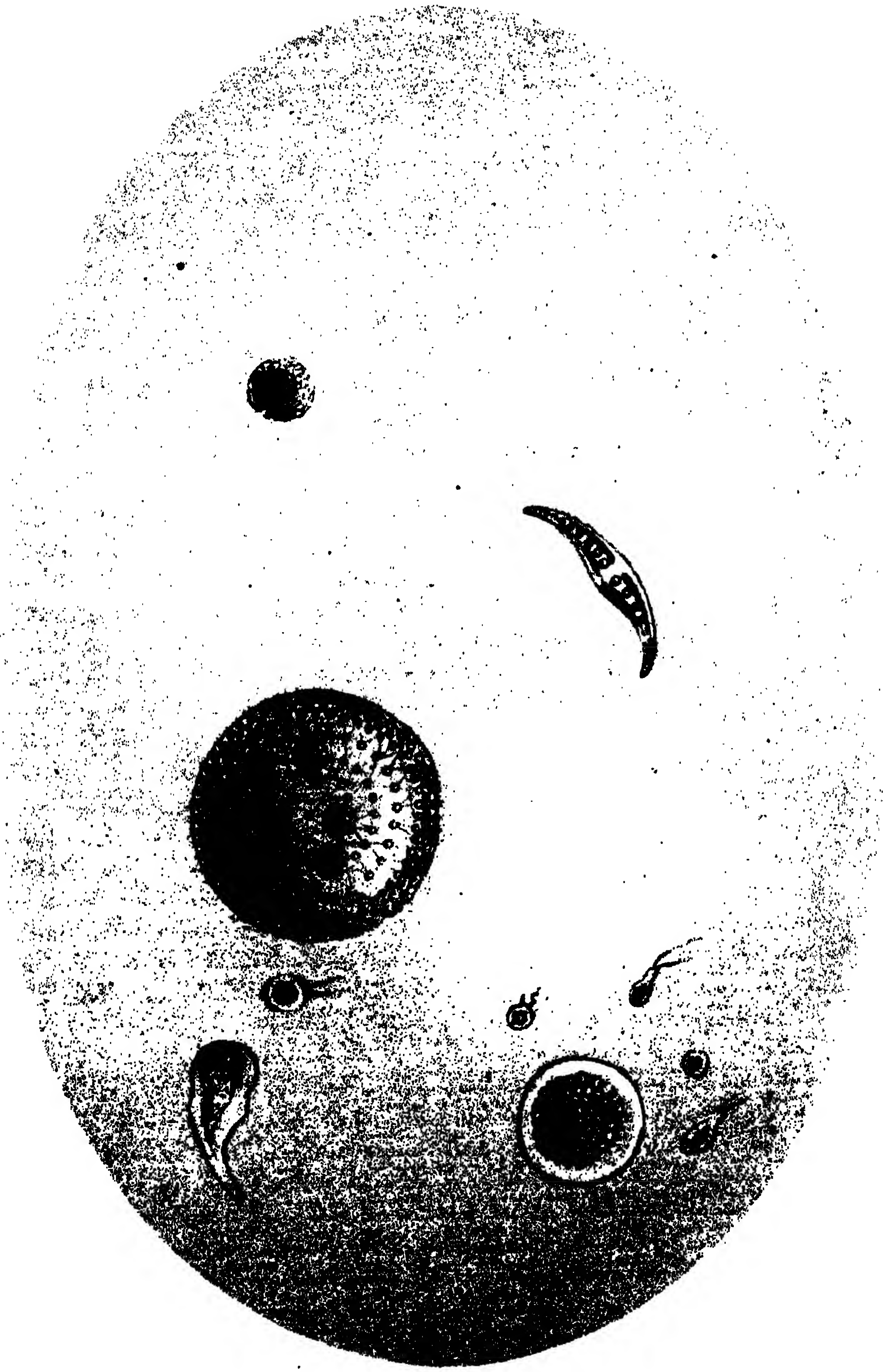
It is nearly ten years since I experienced this pleasure, but I recollect the circumstance almost as though it were yesterday.

My instrument had cost me about ten shillings, and the substance that I first examined with it was a little of the green scum from a water-cistern behind my house. To find in this suspicious-looking fluid myriads of bright green globules sailing about swiftly in all directions, was as great a surprise to me as it was afterwards to hear that each of these moving specks was a living *plant*, endowed with the capability of moving from place to place in search of suitable nourishment; and that, if I had looked carefully, similar organisms possessing *animal* life would also have been visible. It is, as just stated, nearly ten years since I peered into the microscope; and if the novelty has somewhat abated with increased experience, the loss has been counterbalanced by the gratification with which I observe the delight of others when they first inspect similar objects through the more powerful and complicated instrument that I now possess.

During the hot weather last June we had on a visit with us a young lady who asked me on more than one occasion to "show her something under the microscope;" and having postponed the fulfilment of her wish until the warm weather had called into life most of the denizens of the pools, I one morning sallied forth with my ring-net and pocket lens in search of something interesting, and on my return fixed the same evening for the exhibition.

As the time approached, conjectures multiplied as to the character of the "animals" that would be found in the water; and, immediately after tea, I retired to my study, to investigate before exhibiting the contents of my bottle.

This did not occupy much time, for my fishing expedition had



been most successful, and I had little difficulty in preparing a slide that contained a variety of microscopical forms.

Displaying these to the best advantage, I called our young visitor, whose curiosity, I was told, had meanwhile been finding vent in more conjectures, and who soon arrived, in company with one or two members of my family.

In order that the reader may be better able to understand what followed, I have annexed a sketch of some of the forms as they appeared in the instrument, but must add that it gives a very inadequate idea of the scene that presented itself (pl. v.). The brilliant colours of the objects, chiefly of the brightest green, their varied movements, and the blaze of liquid light in which they floated—all are gone, and only the inanimate likenesses are here portrayed.

"Well, what do you see?" I asked, as she bent her head, astonished, over the instrument.

"See? why, this might be the secret haunt of some bright fairy, whose magic influence is at work down there!"

"And can you recognise no power above a fairy's in that scene of hidden wonders?" I remarked.

"True, true," said she; "but what are all these living shapes? Is this a microscope, or telescope? Why, surely, these must be the heavenly bodies!"

She raised her head to look again at the slide, on which, however, she could detect nothing beyond the drop of water covered with a thin square piece of glass.

"Look once more into the instrument before the objects leave the field; for I may not be able to show them to you so favourably grouped again."

"Well, I see a little globe, green and bright as our own beautiful world, revolving slowly on its axis; but its brilliant hue is here derived from countless emeralds that stud its surface; and, bless me! she is indeed a 'mother earth,' for I see several more such globes revolving within her body! And yonder is the moon in her first quarter; and below, Jupiter, with his four satellites;—but, they are flown—no, here they are again, whisking about as gaily as ever.

And that must be the sun, that pale yellow sphere with diverging rays.

But what is this amongst the heavenly bodies? 'Tis a double cross!"

All present appeared to enjoy her surprise, but none more than I; and I could not help laughing at each new exclamation of delight.

"Now," I remarked, after her surprise had somewhat abated, "I must to some extent break the charm. The beautiful revolving globe is *Volvox globator* (only the Latin designa-

tion of a 'rolling sphere'). It was formerly known as the 'globe animalcule;' 'tis, however, not an animalcule at all, but one of the lowest forms of vegetable life."

"What!" she exclaimed; "a plant? Why, it lives—it moves."

"All plants live, in one sense, and many of the lowest possess the power of locomotion. There are some living forms to which naturalists have not yet been able to assign a definite position, either in the animal or vegetable kingdom; but this one is now generally recognised as a true plant. So also your 'moon in her first quarter;' it is *Closterium moniliferum.* I am sorry the name is not more homely; but it means the moniliferous, or necklace-shaped Closterium (from the fancied resemblance between the row of globules within it, and a necklace). Another species of Closterium is called *lunula*, but it does not resemble the moon as much as this one.

The object you called Jupiter, the smaller globe, is a young Volvox in process of development—also a plant, therefore; and its 'satellites' are the moving germs of another lowly plant, *Protococcus viridis*, whose myriads of myriads impart to the surface of the rain-water in cisterns that green tinge which you must frequently have noticed. They subsequently lose their power of locomotion, and, settling down at the bottom of the vessel, they assume a reddish hue.

The double cross, *Staurastrum gracile*, the graceful Staurastrum,* is another of the same order of plants† as Closterium; but your 'Sun,' which is actually designated *Actinophrys Sol* (the radiating sun), from its resemblance to the source of light, is one of the lowest known forms of *animal* existence.

One of the most remarkable objects in the field has, however, escaped your notice, and that is the insignificant slimy-looking mass a little to the left of Volvox."

"What! do you mean that which resembles the map of South America in miniature, and seems to be constantly changing its shape?"

"Precisely so; and I am glad you have descended from the skies, and can, at length, find something on earth with which to compare it, even though it be a continent!

It *does* continually change its shape, and hence its name *Amœba*, from a Greek word denoting that it alternates; but I must beg you to let it rest at present, and if, moreover, you will put aside the microscope, I will endeavour to describe,

* This name is derived from two Greek words, signifying a "cross" and a "star."

† The Desmidiaceæ. (See Ralf's "British Desmidieæ.")

as popularly as I am able, some of those lowly forms of vegetable existence that have so greatly excited your admiration."

My young visitor expressed her readiness to give me her attention; and, in the hope that the reader will do the same, I venture to proceed with the account of our conversation.

"To begin at the beginning. You are of course aware of the difference which exists between a *physical* and a *vital* force—the power that causes an apple to fall to the ground, as distinguished from that which causes it to grow; and you doubtless know that when we see in an organized fabric a vital energy at work, operating irrespective of the physical laws, or even in opposition to them, we call that energy '*life*.'

Thus, for example, if a tree were to lose one of its branches by the blow of an axe, the *physical* force that we call attraction would cause it to fall heavily to the earth; but if, through the *vital* properties of the tree, a fresh branch were put forth near the stump of the old one, it would in all probability grow in the opposite direction to that in which the latter fell: the *vital* power of growth being in this instance superior to the physical power of attraction.

Now, although these forces are apparently distinct in their nature, yet they are closely interlinked one with the other, and every day we find a nearer and nearer relationship, if I may so call it, between them.*

However interesting this subject may be, I cannot dwell upon it this evening, and must now tell you that the force or energy termed 'life,' is, practically speaking, first called into operation in a minute cell, or capsule; and that not only all plants, but also the bodies of all animals, are made up of an assemblage of such cells, more or less modified in form and character.

I say 'practically speaking,' because life may be found in bodies that do not even lay claim to the designation of a cell, as that Amœba, for example, which you found to be little else than a speck of slime; and yet *it* possesses a vital power sufficient to enable it to digest its food and grow.

However, even scientific men are satisfied to regard the 'cell' as the lowest form of life; and those cells that possess animal properties they have grouped together under the title of PROTOZOA, from two Greek words signifying the 'first animals;' whilst those exhibiting the characteristics of the vegetable kingdom they call PROTOPHYTA, or the 'first plants.' The little objects that you compared to Jupiter's satellites, which moved so

* See Carpenter's "Address on the Correlation of Physical and Vital Forces," delivered at the Royal Institution of Great Britain.

rapidly about the smaller Volvox, were four such cells endowed with the power of locomotion, in order that they might move about in search of their proper *pabulum*, the scientific word implying food, but a more appropriate one than the latter in this case, for we can hardly say their 'food,' inasmuch as they are, as I have already told you, not animals but plants. Before our investigations are complete, I dare say I shall have an opportunity of showing you similar forms possessing the properties of animals."

"But tell me, pray," my young pupil asked, interrupting me, "by what means are you able to distinguish between a plant and an animal, if both possess life and motion? and both, in this instance at least, consist of a single cell. If you place before me a man and a tree, I have various means of distinguishing which is animal and which vegetable; but in this case I confess I should be puzzled to know one from the other."

"Ay; and wiser persons than you or I are puzzled every day with the same problem. As I told you before, there is a vast number of living forms whose nature, so far as its being animal or vegetable, is still undecided; and I should have great difficulty in referring you to any work on Natural History that would enlighten you in this respect. One author will tell you that the distinction consists in the animal possessing a stomach for the digestion of food, whilst the plant has no such cavity. Another, that *sensation* distinguishes the animal from the plant; a third, that in vegetable substances we always find *starch*, but not in animal forms; a fourth will say animals inhale oxygen and exhale carbon, whilst in the vegetable kingdom the reverse is the case; and a fifth will cut the Gordian knot by boldly asserting that there is no appreciable difference between the lowest forms of animal and vegetable existence.

But now to what 'new' conclusion do you think naturalists are hastening in this respect?

Simply this. Animals are nourished by organized substances, either alive or in a state of *partial decomposition*, whilst plants derive their sustenance from *in*organic substances, such as phosphate of lime, ammonia, water, &c. This definition of the difference between the two classes of living objects is not quite satisfactory, but it is, I think, the best that you will find in the present state of our knowledge. And, curiously enough, it accords with the oldest theories on the subject; for, as plants were first created and then animals, plants must have derived their support, as they do now, from inorganic substances—carbon, water, nitrogen, &c.—which they extract from the earth and atmosphere; whilst animals feed upon organized compounds, which they ingest and work up into their own substance, either in stomachs perfectly formed and

constant, or in imperfect temporary cavities framed for the purpose.

And this distinction holds good in the perfectly-formed animal and vegetable, such as the man and the tree, as well as in the lowest known types of either kingdom; so you see we are reminded at every step of the unity of those laws by which nature is controlled.

Bearing in mind that it derives the nutriment that ministers to its growth from the inorganic constituents of the water, you will, of course, see that our little vegetable cell must not remain long in one place, lest it should exhaust the supply around it, and it is therefore furnished with one or more little whip- or hair-like members, by means of which it moves rapidly from place to place. If you had carefully examined the little forms that moved about the Volvox, you would have perceived these members of locomotion. (Pl. v. and pl. vi. fig. 1.)

The '*cilia*' (as these hair-like fibres have been very appropriately called, from the Latin word *cilium*, an 'eyelash') have an inherent contractile power, similar to that of the sensitive plant, and so long as there is vitality in them they are in constant motion. You may, perhaps, be surprised when I tell you that we have vast numbers of them at work in various parts of our bodies, which, unconsciously to ourselves, keep certain of the fluids in active circulation; and in the living oyster they may be seen to perfection: so, you see, they are common to animals as well as plants. But to return to our little living cell.

If there is any subject into which scientific men have imported a terrible array of hard words, it is into the history of this simple little object; and if I were to begin to discourse learnedly to you about 'primordial utricles,' 'cytoblasts,' 'endoplasts,' and 'protoplasma,' I am sure you would all be fast asleep before I had finished my explanation of the meaning of one of these terms in connection with the anatomy of a vegetable cell.

Without at all sacrificing to scientific accuracy, however, I am fortunately able to borrow a very clear and simple description of this object from a work recently published in connection with the microscope.* It is '*a closed sac, composed of an* (*originally*) *imperforate membrane formed of the chemical substance called cellulose, this membrane enclosing fluid contents so long as the cell retains its vitality.*'"

"That may be a very clear and simple description of a vegetable cell to you or any other scientific student," said my young pupil, "and I *believe* that *I* understand its meaning;

* Griffith and Henfrey's "Micrographic Dictionary," page 126, article "Cell." Van Voorst. 1860.

but if you could compare it to some object that has come under our observation, I think you might render it still more comprehensible to us all."

"Well," I continued, after a little consideration, "I will endeavour to be more familiar in my exposition, and will give you a simile, not a very pleasant one perhaps, but one that will enable you to form a clear conception of its structure. You have seen those little gelatinous capsules containing castor-oil, sold by druggists, have you not? Suppose the gelatinous husk or shell of one of these to be thick, soft, transparent, and very elastic; the contained castor-oil to be more viscid than it is, and floating in it a number of little green granules; lastly, imagine the whole capsule to be globular, and so small as to be invisible to the naked eye;—you will then be picturing to yourself that wonderful little mechanism, of which the secret spring is 'life,' the lowest living thing that has the power of growth and reproduction." (Pl. vi. fig. 2.)

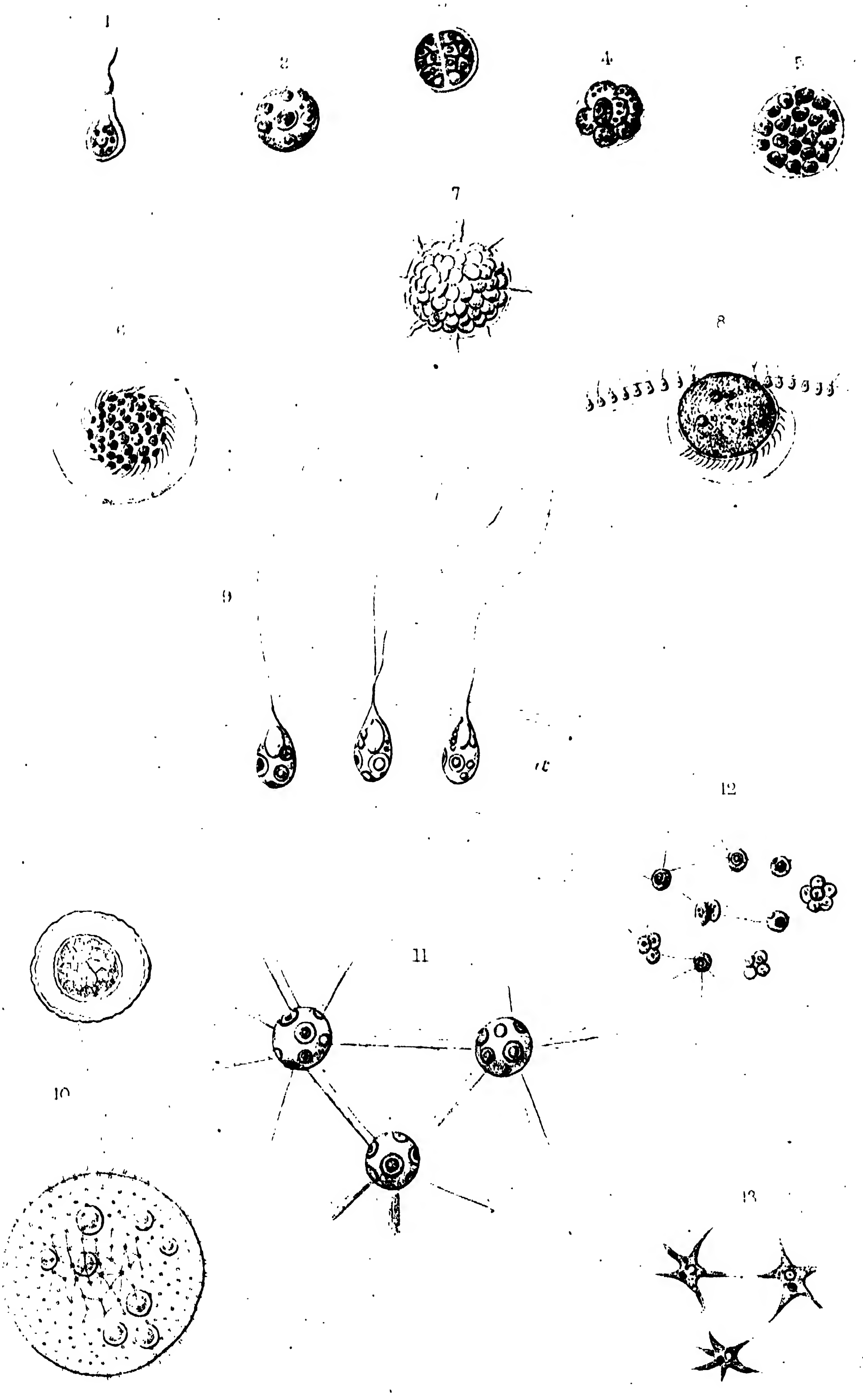
"But you just now described one of these cells as 'a closed imperforate sac;' how, then, can it grow and reproduce? indeed, how does it imbibe nourishment?"

"I will answer the last question first. If you fill a bladder with water, are you not aware that the moisture will pass through it, although it is closed?"

"Certainly; and that reminds me that I have often been surprised at the manner in which water exudes through those earthenware 'water-coolers,' giving to the material of which they are made a deeper tinge than when it is dry."

"Precisely so," I continued; "and this is called *exosmosis*, from two Greek words, that signify, 'an impulsion outwards.' If, however, the bladder or earthenware bottle were empty, and you immersed it in water, the moisture would in like manner penetrate into the interior, and this is called *endosmosis*, or 'impulsion inwards;' but we may go still further. 'If two fluids of unequal densities are separated by an animal or vegetable membrane, the denser will attract the less dense through the membrane that divides them. This property is called *endosmose*, when the attraction is from the outside to the inside; and *exosmose*, when it operates from the inside to the outside of the body acted upon.'* This is the principle—now for its application. The vegetable cell, as I told you, contains a dense fluid, and so it attracts the moisture from without through its capsule or cell-wall, draws from it the materials necessary for its growth (ammonia, carbonic acid, &c.), and gives out oxygen through the same medium. This is the mode in which a cell is nourished; and, although it would be too great a digression

* Brande.



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to explain how and wherefore, I may add that upon this principle, too, the substances that we eat and drink are ultimately distributed through our bodies; for it is by means of simple cells that they are taken up and conveyed into the blood: so you see, that small and apparently insignificant organisms often perform very important offices.

So much for the mode in which the cell is nourished: now a word as to its growth and reproduction, and then, I think, you will have made sufficient progress in vegetable physiology to enable you at least to understand the history of *Volvox globator*.

Immediately within the capsule, or covering of the cell, the little granules are formed, which, I told you, float about in the fluid contents of the cell. These increase in number, and the external gelatinous case becomes distended, and adapts itself to the growing substance within. The latter soon divides into two parts, either in a direct line across the cell (pl. vi. fig. 3), or obliquely; and these two parts, which are in reality two new cells, burst the outer coat, and swim away (furnished with two cilia for the purpose) to be nourished, subdivided, and reproduced in the same manner as the parent cell. There are other stages into which they pass; but this is the first and essential process by which they are multiplied with incredible rapidity.

The chief difference between the simple little cell, that I have been describing to you, and *Volvox globator* (pl. v. large globe), the 'rolling globe,' is that the latter is an aggregation or assemblage of the former, which, instead of escaping after they have subdivided, *remain permanently attached to one another*, and form that beautiful little globe which has so greatly excited your admiration this evening. You will recollect that it presented the appearance of a crystal ball studded all over with objects resembling emeralds, connected together by delicate lines, and within it there were eight smaller globes, of a deep green colour. A smaller globe also, similar to those within the larger one, you will remember, was revolving a little to the right of the latter,* and I will now endeavour to explain to you the relationship existing between the globes.

First of all a simple vegetable cell filled with green granules (pl. vi. figs. 2, 3) undergoes the process of subdivision into two parts, as already described. Then, instead of these two parts becoming detached from one another, each again subdivides, and so the process of 'segmentation,' as it is called, goes on (pl. vi. figs. 4, 5, 6, 7) until the whole mass of cells assumes the appearance of a mulberry. Unlike the mulberry, however, it is *hollow*, and is surrounded by a transparent gelatinous capsule (pl. vi.

* The reader should refer to the plate when necessary.

figs. 6, 7) resembling that of the original cell before subdivision commenced. Here and there we find 'cilia' (the little locomotive fibres already described) protruding through the outer gelatinous coat; and these cilia, which belong to some of the divided cells, cause the whole mass to revolve by their simultaneous movements. They do not, however, make their appearance until growth has considerably advanced.

When the process of segmentation is complete, and as many of the young cells (which are called 'zoospores,'* or 'gonidia') are present in the mulberry mass as are afterwards found upon the mature Volvox, then the transparent enveloping membrane begins to expand, and the green gonidia spread wider and wider apart, but remain connected together by thread-like filaments, which become thinner and thinner as the distance between the cells increases, until at length they are hardly traceable even under a high microscopic power; and then the Volvox presents the appearance of a beautiful crystal globe studded all over with ciliated cells or gonidia (pl. v.).

You may easily understand this mode of development if you picture to yourself one of those hollow india-rubber balls protected by a network, that are used as toys by children; and suppose the network on one of these balls to be elastic, and so completely covered with green beads that the ball is rendered invisible. Now, imagine the ball to be gradually distended with air, and the beads thus stretched farther and farther apart, and until the *network* is lost to view, and only the beads are perceptible, studded all over the thin distended globe. This will enable you to understand the circumstances under which Volvox is developed, and assumes its beautiful appearance.

To revert to our living Volvox, however, the gonidia, or green cells, which *appear* to be upon its surface, are in reality *imbedded* in the gelatinous membrane that forms the globe, the cilia alone protruding through the latter (pl. vi. fig. 9); and it is these gonidia that undergo subdivision or segmentation in the manner described, forming the smaller globes (the young Volvoces, in fact) that roll about within the larger one; for they grow *inwards* (pl. vi. fig. 8), and as soon as they have attained a certain growth, they become detached and fall into the cavity (pl. v. larger globe).

The number of the smaller globes is usually eight; and as these soon become too large for the parent to hold them, the latter bursts and sets them free, after which they move about in the watery element, and in like manner give birth to similar forms. But what is most remarkable, is that even whilst the lesser globes are still within the parent, they sometimes produce a third series, so that a parent Volvox often carries about with it two generations one within the other.

* Very inappropriately, for the word signifies "animal germs."

This, you will perceive, beats our ivory puzzle-balls, which you have doubtless been accustomed to regard with wonder; and if the Volvox, which is just visible to the naked eye as a little green speck, has caused you so much admiration, what will you say when I tell you that the little green cells of which it is composed are quite as highly organized as the Volvox itself?

When examined with a high microscopic power, these gonidia are found to be pear-shaped and imbedded, as I said before, in the gelatinous membrane that forms the globe, through which the vibratile cilia alone protrude.

Near the apex or point of the pear-shaped drop is a little bright red spot, supposed by Ehrenberg to be an eye-spot (pl. vi. fig. 9*a*)."

"Ehrenberg! who is he? and if it has an eye, how can your Volvox be a plant?"

"At some future time I may tell you who Ehrenberg is; and as to the so-called eye-spot, it is common to many plants, and has nothing to do with vision; its nature is not clearly defined.

In the contents of the cell, composed, as already stated, of green granules, there is a curious little transparent cavity, in all probability filled with fluid; and this contracts and expands rhythmically at intervals of about forty seconds, the contraction taking place suddenly, and the dilatation slowly; and now I must add that this contractile cavity is found not only in some other known plants, but also in a great number of the lowest animals; so you see by how many different features these two forms of life are linked together. It is no wonder that, even now, men of the highest intelligence differ as to the true nature of a great number of types; some believing them to be plants, and others animals.

I fear, however, that you will be wearied with my lengthened account of this wonderful little living plant, and shall, therefore, draw the story of its life to a close.* If you examine it in autumn, you will find that the inner globes present quite a different appearance to what they do in summer. Instead of possessing a green colour, they are of a brownish orange, and the transparent envelope in which they are clothed is much thicker than it was in those that were developed during the summer. This is the winter garb of Volvox (pl. vi. fig. 10); in this state the germs rest until spring, when they are resuscitated; but how they come at that season to assume their emerald appearance, and what changes they then undergo, remains, along with many other features connected with the history of the plant, a

* During its transformations, Volvox presents a great variety of forms, some of which are delineated in plate vi., figs. 11, 12, 13; the last being the *amœba* or changeable form, in which the little cells lose their permanent shape, and resemble the lowest forms of animal life.

mysterious problem, still to be solved by persevering microscopical observers.

Although each of the little plants is, as I have already said, visible only to the practised eye without the aid of the lens, yet the water in which they are found is often tinged with green, in consequence of their vast numbers; so you see that whether we look up into the heavens and inspect the bright revolving worlds above, or down into the waters, and there consider the little animated globes, we still find innumerable evidences of His handiwork."

Bibliography: Pritchard's Infusoria (new edition); Micrographic Dictionary; Carpenter's "Revelations of the Microscope;" Hicks's contributions to the "Microscopical Journal;" Williamson, Trans. Manchester Philosophical Society; and other papers by Busk, Cohn, &c.

IRON AND STEEL.

BY ROBERT HUNT, F.R.S.

FROM the buried palace of the kings of Assyria, Mr. Layard sent to England some good examples of art-manufacture in metal. With these we have at present no concern, except for an important piece of information which one specimen conveyed to us. This specimen was a casting in bronze of the fore leg and the foot of a young fawn, very delicately modelled. It evidently at one time formed a support to a table or lamp, or it may have been to some household god. This example of Assyrian metal-work was so slender, and yet so strong, that it was thought there must be some peculiarity in the composition of the bronze, to enable it to support, without bending, the weight which probably rested upon it. A fragment was analyzed, and found to consist of copper 88·67 grains, and of tin 11·33—about the usual composition of the ancient bronzes. In cutting off the fragment for analysis, a curious discovery was made: a rod of *iron* passed through the leg, as a core, around which the bronze had been cast.

This proves not only that iron was known, but that it was commonly employed where strength was required, when the line of Belus tyrannized over all the land, from the mountains of Judah to those of Caucasus. It is not intended to discuss the question, whether the sacred historians, or the Greek poets, have described the metals which we now call Iron and Steel; it is enough for us to know, that, at a very early period, there existed a knowledge of some of the best qualities of iron, and that it was an article of manufacture. The point to which we desire to call especial attention is, that man has certainly been using iron for nearly three thousand years,—that he is still ignorant of the causes producing many of its peculiarities,—and that our best chemists are at this moment disputing whether Carbon or Nitrogen is the element which converts iron into steel.

England is peculiarly the land of iron manufactures. In no part of the world has iron ever been produced in such enormous quantities, and in such a variety of qualities, as in the United Kingdom. Our blast-furnaces are pouring out annually a molten stream of nearly *four millions of tons* of this metal, and our Mills and Forges are—like the caves of the Cyclops—for ever boiling and glowing—as this is being converted by the might of man's industry into merchantable iron and steel.

The command of the Creator to man was that he "replenish the earth and *subdue it.*" That he is fulfilling this, will, we think, be admitted by all who will reflect on the perils of the miner's subterranean toils, to procure a crude and uninteresting stone,—and will follow us as we endeavour concisely to describe the more important processes to which this is subjected, and the purposes to which its products are eventually applied.

Let not our readers suppose that a technical paper on the properties of iron is intended. We refer all who desire detailed information to the works of Percy, of Fairbairn, of Phillips, and others; our purpose being, to interest the least technical mind, by describing the curiosities of a manufacture which has given to England her commercial supremacy, and by the power of which she holds the key to all the markets of the world.

Iron has been made in England from the earliest times. In the same manner as the native of the Himalayan mountains now builds his rude furnace of clay, lights his wood fire, and charges it with iron-ore,—urging it by the blasts of his sheep-skin bellows, until he obtains his small lump of "wootz,"—so did the first iron-makers in Britain—probably before Cæsar came; and they have left us their "old cinders," and their "bloomaries," to inform us how perseveringly, even in the childhood of our race, our forefathers sought to avail themselves of the mineral treasures of the land.

In the Forest of Dean, on the hills of Cleveland, in the valley of Furness; wherever, indeed, man now pursues his search for the ores of iron, he finds the evidences of ancient workings. The history, however, of iron manufacture in this country is extremely obscure. That it was considered of great importance, is proved from the circumstance that the chief smith was an officer of considerable dignity amongst the Anglo-Saxons. In the courts of the Welsh sovereigns, the king's smith sat next the domestic chaplain, and he "was entitled to a draught of every kind of liquor that was brought into the hall;" and at the time of, and long after, the Conquest, every military chieftain maintained his smith, to whom many peculiar privileges were allowed. Tradition points to the Northmen as the most important iron-smelters; the heaps of scoriæ existing in many parts of England being still called "*Danes' Cinders.*" When we begin to have any true history of these metallurgical operations, we find the seat of our iron manufacture in the eastern and south-eastern counties. The Green-Sand formations, which extend from the Humber, on our north-eastern shores, to the southern coast, near Dorchester, yielded abundance of iron-ore; and the counties of Suffolk, Essex, Kent, and Sussex, were thickly covered with timber trees, from which charcoal in large quantities was made. With these facilities for making iron,

numerous furnaces sprang up, and there appears to have been a steady increase in the manufacture of iron and steel in England.

In 1615, Dud Dudley informs us that there were 300 blast-furnaces in active operation, producing in that year 180,000 tons of iron, for which 144,000 tons of charcoal were required; to produce which, 17,310,000 cubic feet of timber were necessary. At the same time, according to the same authority, 500 forges and mills for refining were at work. From this statement we learn that each furnace yielded somewhat less than twelve tons of iron a week. Dudley again informs us of his proceedings at Hascobridge, in the parish of Sedgley, after he began to smelt iron-ore with coal, "in which work he made *seven tons of iron* per week, the greatest quantity of pit-cole iron that ever yet was made in Great Britain." The difference between the powers of production then and now will be evident when we state that 400 tons of pig-iron have been, on many occasions, made in one week from the best modern blast-furnaces. Even at the beginning of the seventeenth century, the rapid exhaustion of the forest trees, by the demands of the blast-furnace, was a subject of serious consideration. The amiable Evelyn, in the sixteenth century, regrets that Nature had placed her iron-ores near flourishing forests; and, describing some of his loved trees, he exclaims: "What a pity such goodly creatures should be devoted to Vulcan!" At this time Essex appears to have been the centre of our iron industries, and Thaxted—now known only for its beautiful church—was the emporium of our steel manufacture, and possessed many especial privileges in consequence. There were, however, several extensive, and then important, works in the Forest of Dean, in some of which Oliver Cromwell appears to have been an active partner.

Wood was failing: then Simon Sturtevant and John Rovenzon made much noise about their experiments on smelting iron with pit-coal. They did not succeed. Dud Dudley followed them; he obtained some patent rights mainly on the plea that "if wood and timber should decay still and fail, the greatest strength of Great Britain, her ships, &c., and his Majesty's navies and men-of-war, for our defence and offence, would fail us." With much industry and irrepressible zeal, he pursued his experiments on "making of iron with pit-cole or sea-cole," and eventually succeeded in producing good metal. Dudley became the founder of the remarkable industry which distinguishes South Staffordshire. The forests were now allowed to grow, the demand for charcoal fell off, the iron manufacture of eastern England passed to the Midland counties, the steel trade left Thaxted and became the staple of Hallamshire, now better known by its chief town, Sheffield.

In Dud Dudley's time, 300 blast-furnaces produced 180,000

tons of iron in each year: in our time, 600 blast-furnaces—the number now at work—are pouring out annualy nearlly 4,000,000 tons of pig-iron. Besides those, three small furnaces exist in the neighbourhood of Ulverstone, and one in Scotland, in which charcoal is still used as the fuel: it rarely happens, however, that more than one of these is "in blast" at the same time.

The enormous development of the iron manufacture of Great Britain appears to have been due to the circumstance to which Dud Dudley was the first to direct attention,—that our best iron-ore, and good coal for smelting it, are, in many cases, associated. Dudley's quaint arguments to persuade the king to grant him a patent are amusing. Amongst other things, he says, as a reason why his prayer should be heard,—"Because in most of the coale mines in these parts, as well as upon the Lord Dudley's lands, are Coals, Ten, Eleven, and Twelve yards thick; the top or the uppermost cole or vein gotten upon the superfices of this Globe, or Earth, in open works. Under this great thickness of coal is very many sorts of Iron, Stone, Mines, in the Earth, Clay, or Stone earth, like bats, in all four yards thick; also under these iron mines is several yards thick of coals," &c. &c. Dud Dudley, as he was the originator of the process of smelting iron with pit-coal, so he was the type upon which all iron-masters since his time have been built. To the untiring industry, and that indomitable force of purpose which has ever led them through periods of deep distress,—and to that irrepressible will which knows no difficulty,—must be referred the position which England holds amidst the metallurgists of the world.

In parenthesis,—we are constantly told that many of the continental states have proved themselves to be superior in metallurgical knowledge to ourselves. In answer to this, let us always remember that their superiority exists in the clever *books* they have written: our supremacy is secured by the *work* we have done. Nature has given us the raw material, and British heads and hands have moulded it into every possible form, whether for use or ornament. We have practically performed the trick of transmutation, and converted our iron into gold, while other people have been writing ingenious theories on the possibility of doing it.

This essay would be incomplete, if it did not describe—although it can do so but briefly—the sources from which we have derived our enormous supplies of iron ore.

In South Staffordshire exist the beds of argillaceous, or clay-band ironstone, to which Dud Dudley drew attention, interstratified with the coal. We have the same conditions in Wales, in Yorkshire, in Derbyshire, and other of our coal-producing counties. In Scotland, Mr. Mushet drew attention to the "black-band ironstone," and thus founded that large industry

which marks the country near Glasgow. These were the sources from which we drew all our carbonaceous iron ores, from which the greatest proportion of British iron has been made.

Another carbonate of the protoxide of iron has, within a few years, attracted attention. Now and then a few ferruginous stones were found strewn over the beaches on the north-eastern coast of Yorkshire, but a long time elapsed before it was discovered that they had fallen from a higher level, and that a massive bed of this material could be traced by its outcrop for miles and miles along the escarpments of the Cleveland Hills. From this district we now draw annually more than a million and half of tons of iron ore; and many are the fitful tongues of flame which indicate the existence of the iron-furnace over this once solitary region.

From the neighbourhoods of Whitehaven and Ulverstone are obtained the red Hematite ores, or anhydrous oxides of iron, so well known for their richness, and highly appreciated for mixing with inferior ores, and improving the quality of iron. The deposits of this beautiful peroxide of iron occur in the Whitehaven district in a most massive form, usually in the Millstone Grit and the Mountain Limestone series, filling in vast caverns, which had been previously formed. In the Ulverstone district the iron ore is equally rich, but it is not of so coherent a character; and it may be inferred, from the order of occurrence, that the ore had been precipitated from water flowing through clefts in the rocks, or reposing in large lakes.

The brown hematite ore, or hydrated oxide of iron, of Dean Forest has been formed under somewhat similar conditions, and that which has lately been discovered at Llantrissant is of a like character. The older rocks of Somersetshire and Devon yield both the peroxide of iron and that peculiar form of carbonate which is commonly known as Spathic ore. On Exmoor, and over the Brendon hills, large works have been established, and in the south of Devonshire, near Newton Bushell, at Brixham, and near Kingsbridge, these ores are worked. Again, in Cornwall, the Restormel iron mine,—dignified with the title of Royal, because her Majesty the Queen once explored its subterranean recesses,—and numerous mines around St. Austell, produce the brown hematite. This and Spathose ore are also largely mined on the northern coast of Cornwall, where an iron lode, 100 feet wide, is seen in the cliff, which has been traced for many miles inland. Even yet we have not told all our known resources. At Whitby, in Yorkshire, above the beds which clearly correspond with those of Cleveland, occurs a more recent bed in the Oolitic rocks. This may be traced towards the Humber; and on the southern side, in Lincoln-

shire, at a few inches below the surface, it spreads out in a bed of peroxide of iron, varying from six to twelve feet in thickness. At Scunthorpe this is largely worked, and also near Kirton-in-Linsey. A formation similar in character, and probably the same in geological conditions, is seen at Peterborough and at Stamford. It then spreads over Northamptonshire and the adjoining counties, where it is worked extensively. At Westbury, and at Seend, in Wiltshire, immense deposits of iron ore again occur, and at both of those places blast-furnaces have been built, which make iron entirely from the ores of each locality.

Such is a very rapid sketch of the more important sources of our large supply; in addition to which we imported, in 1860, 23,112 tons of foreign ore. Iron and coal are the great supporters of British power. On these our manufacturing capability depends; and as this power of production places us now as the first of commercial nations, we must, as the power weakens, recede in the scale. The following table shows the present rate of exhaustion going on in our coal-fields and our iron deposits:—

TABLE OF IRON-PRODUCING POWER IN 1860.

Name of County or Country.	Iron Ore Raised.	Pig-Iron Produced.	No. of Works.	Furnaces in Blast.	Coals Produced.
	TONS.	TONS.			TONS.
Northumberland..	12,500	69,093	8	7	18,244,708
Durham		340,921	19	37	
Yorkshire	1,727,019	346,765	23	50	9,284,000
Lancashire	520,829	81,250	4	8	11,350,000
Cumberland	468,781	87,950	5	8	1,171,052
Derbyshire, &c. ...	370,500	125,850	16	23	5,670,000
Shropshire	165,500	145,200	13	26	850,500
Staffordshire	1,523,929	616,450	80	133½	7,648,300
Northamptonshire	95,664	7,595	2	3	—
Gloucestershire ...	90,466	26,458	4	4	4,350,900
Wiltshire	76,201	21,875	2	4	—
Somersetshire ...	24,101	1,960	2	1	942,000
North Wales	85,097	49,360	8	8	1,750,000
South Wales	630,705	969,025	49	147	6,254,813
SCOTLAND	2,150,000	937,000	33	131	10,900,500
Cornwall	23,953	—	—	—	—
Devonshire.........	3,836	—	—	—	10,500
Hampshire	6,119	—	—	—	—
Warwickshire ...	19,500	—	—	—	—
Oxfordshire	5,833	—	—	—	—
Lincolnshire	16,892	—	—	—	—
Isle of Man	1,671	—	—	—	—
IRELAND............	106	—	—	—	119,425

The question of the duration of our coal-fields has been asked, and, most unfortunately, it has been answered by loose guesses and random speculations, which are not worthy of any reliance. The means of determining the problem with accuracy exist; but they have not been made available. Quite independent, however, of this question of duration, we should open our eyes to the fact, that coals are becoming every year more costly; and they must continue to increase in price; this being in strict accordance with the old Staffordshire proverb, which says, "*He that liveth longest let him fetch fire further.*" As the workings extend, the cost of obtaining the coals must increase; and with this, either the profits of the manufacturer must diminish, or the price to the consumer advance.

In 1860 we smelted 8,024,205 tons of iron ore, the value of which was about £2,466,929; this produced 3,826,752 tons of pig-iron, valued at the mean average market price of the year at £12,703,950. Of this we exported, in the form of pig-iron, 342,567 tons, reserving 3,484,185 tons for manufacture. Upon this hundreds of puddling-furnaces were unceasingly employed, converting the crude-cast pig-iron into malleable iron; and mills, Cyclopean in every sense, were rolling this into bars, rails, and sheets.

Did our space permit us, we should have desired to examine with some care the conditions of the iron ores of this country. It does not; and we therefore, with satisfaction, refer to the "Memoirs of the Geological Survey," which embrace "The Iron Ores of Great Britain." In these will be found analyses of all the important iron-stones, made with the utmost accuracy, under the care of Dr. Percy,—the cost of this great work having been mainly met by a handsome contribution from Mr. Samuel Blackwell, of Dudley, to whom, it will be remembered, was due the valuable collection of iron ores which were in the Exhibition of 1851, and are now in the Museum of Practical Geology.

Leaving, therefore, the character of our iron ores to be sought for from the source indicated, it is necessary that the conditions of iron, as a manufactured article, should engage our attention.

Iron is the most common of metals; we have been manufacturing it for hundreds of years, and a large amount of mental labour has been bestowed on its examination. Still, it is doubtful whether iron in a state of absolute purity is known to us. If we take pure oxide of iron, and reduce it in a tube, at a red heat, by passing hydrogen over it,—the only method by which the pure metal can be got,—we obtain a spongy mass, which takes fire spontaneously upon exposure to the air. We know not if this is due to the porous character of the mass,—by which it acts mechanically on the oxygen of the air, as does spongy platinum, or if it is owing to the intense affinity of the

pure metal for oxygen. The purest commercial form of iron still contains about half per cent. of carbon, some nitrogen, with traces of silicon and other metals. Two analyses of cast iron, of each variety—that is, "*cold-blast*" and "*hot-blast*,"—will convey a good idea of its composition.

	COLD-BLAST.		HOT-BLAST.	
	1.	**2.**	**1.**	**2.**
Silicon	1·050	1·400	2·500	3·140
Graphite	3·370	3·184	3·520	3·100
Sulphur............	0·024	0·037	0·045	0·090
Phosphorus	0·210	0·314	0·318	0·422
	Metallic Iron, 93·15 per cent.		Metallic Iron, 95·0 per cent.	

It is necessary that we should convey to the reader, who may not be familiar with the technicalities of iron manufacture, some idea of the process by which the metallic iron is obtained, and give some explanation of the peculiarities of the hot and cold blast furnaces. With the mysteries of the *Catalan forge*, the *Fourneaux à pièce* of the French, and the *Stüch-ofen*, or Salamander furnace, of the Germans, we shall not deal; attention will be confined to the ordinary English blast-furnace for smelting iron with coal or coke.

A person who has never visited an iron-making district cannot possibly realize the scene which it presents. Nothing in England is more impressive—we may say, more sublime,—than the "Black Country" of South Staffordshire, as you are carried through it by the railway-train at night. A hundred blast-furnaces are belching forth their giant tongues of flame. The glaring white-hot eyes of *finery-furnaces* and *puddling-furnaces* look out into the darkness in fitful flashes. From scores of chimneys, red-hot vapour rushes wildly into the air, illuminating the ill-defined mills and forges to which they belong. All that is not black as night is intensely hot. Darkness and heat are two giants struggling for the mastery. With small aid from the imagination, the home of the Cyclopean smiths in the very roots of Vesuvius or Etna may be realized, or the Pandemonium of Milton fully pictured on the mind.

"A dungeon horrible—on all sides round
As one great furnace, flamed; yet from those flames
No light, but rather darkness visible
Served only to discover sights of woe—
———————— a fiery deluge, fed
With ever-burning sulphur unconsumed—
With floods and whirlwinds of tempestuous fire."

Such is the external appearance of any of our large iron-works, the introduction to which is through those vast towers,

called blast-furnaces, which stand like the fiery wardens guarding the giant's castle, in those Teutonic legends that still live in Northern Europe. The *blast-furnace*, as usually constructed, is a circular brick tower, about sixty feet high, and at the *boshes*, or widest part, its width varies from fourteen to seventeen or eighteen feet. Its interior section exhibits two frustums of cones, meeting each other at their bases, at the widest part of the furnace; from which point it gradually contracts both upwards to the *mouth* and downwards to the level, where the *tuyères* (small apertures for admitting air) are situated; within this are placed the *fuel*, the *flux*, and the *mine*, or iron ore. The *blowing-in*, as it is called, or the first starting of an iron-furnace, is an operation requiring great experience.

A fire of wood is first lighted on the *hearth*, upon which coke is thrown, and when the whole is ignited, the furnace is filled by pouring in at the month regular charges of calcined iron ore, limestone, and coke. Blasts of air, urged by powerful steam-engines, are blown in through the *tuyères*, and the whole becomes an intensely incandescent mass. The size and power of those bellows will be best understood, by stating the fact, that an ordinary furnace making white iron requires nearly 7,500 cubic feet of air per minute, or it consumes 2,318 tons of our atmosphere in every week.

As the iron ore is acted on by the intense heat produced, it yields up its carbonic acid and its oxygen, and fluid metal flows into the lower part of the furnace, where it is collected and preserved, until a sufficient quantity is obtained for casting.

Moulds are made in sand, consisting of longitudinal channels, called *sows*, from which are formed lateral troughs, named *pigs*. The furnace is tapped by breaking away the clay which closes and secures the *tymp-plate*, on the removal of which, out flows a river of glowing whiteness, rushing onward through the sows, and rapidly filling the *pigs* with iron. The whole of the liquid contents having flowed out, the *tymp-plate* is again secured, and the operation of smelting goes forward as before. Furnaces are kept in blast for many years, yielding regularly from 200 to 400 tons of pig-iron per week; every ton of iron requiring the following proportion of materials, or thereabouts. (Half a dozen examples are given, as they vary at different works, and also with the quality of iron.)

	1.	2.	3.	4.	5.	6.
	CWT.	CWT.	CWT.	CWT.	CWT.	CWT.
Calcined Iron Ore......	48	28	46	35	27	37
Hematite do.	—	10	—	—	10	7
Cinders	—	10	—	—	—	11
Coal	50	42	—	40	—	36
Coke	—	—	34	—	34	—
Limestone	17	14	16	5	15	5

The uninitiated reader must be informed that the *cinders* used are those which are produced in the processes of refining and puddling. They are often very beautifully crystallized, are rich in iron, but contain variable quantities of silicon, alumina, manganese, sulphur, phosphorus—in fact, all the impurities of the iron which are not dissipated by heat.

The difference between the "cold-blast" and "hot-blast" iron, just now referred to, is produced by a contrivance for heating the air before it is urged into the blast-furnace. The introduction of hot, in the place of cold air, in iron manufacture, was effected in 1827, by Mr. James Beaumont Neilson, of Glasgow. It will be evident, upon consideration, that a fire urged with air heated to 572° Fahrenheit's scale, must be more intense than a fire urged by air at the ordinary atmospheric temperature. The result, in practice, has been, that whereas formerly, by the cold blast to produce one ton of pig-iron, 8 tons 1 cwt. of coal, converted into coke, were required; now a ton of iron can be made from the same ore with 2 tons 6 cwt. of coal.

It was contended by many persons, on the introduction of the system of smelting iron by the hot blast, that, although the process might enable the ironmaster to produce a larger quantity of metal economically, yet, in many of the qualities most desirable, the hot-blast iron was deficient. Long, and often angry, discussions ensued, yet cold-blast furnaces went gradually out of use, and the hot-blast apparatus was generally applied. The matter was, at length, submitted to experimental examination at the request of the British Association, Mr. William Fairbairn and Mr. Eaton Hodgkinson having charge of the inquiry. The points to be determined were—1. Direct tensile strength; 2. Compressive strength; 3. Transverse strength; 4. Power to resist impact; 5. Modulus of elasticity, or stiffness; and, 6. Specific gravity. The report furnished shows, conclusively, that the sum of the advantages are in favour of hot-blast iron. The mean ratio of strength in cold-blast iron being represented by 1,000; hot-blast was 1,024·8; and the mean ratio of power, to sustain impact,* being in cold-blast as 1,000, it was 1,226·3 in hot-blast iron. One cause has been indicated, which, no doubt, leads, in some cases, to an inferiority. Heated air exerts a greater reductive power than cold air; consequently, in some furnaces blown with hot air, refractory iron ores, which could not otherwise have been employed, have been introduced into the furnace. They generally contain many impurities, and, consequently, inferior iron has been made. The advantages of hot over cold air, in iron-making, are many; and, without it, the anthracite coal of South Wales and of the United States could never have been employed; whereas this fuel is now becoming every year more valuable.

* The power to resist blows.

In the economy of iron-smelting, the collection of the gases escaping from the top of the blast-furnace, and their utilization, must not be forgotten. The chemical changes which are going on within the conical tower—where incandescent coal or coke, oxide of iron, and carbonate of lime are meeting with the oxygen and nitrogen of the air, at a very high temperature—are of a curious and complicated nature. They have been imperfectly studied. The experiments of Bunsen and Playfair, at the Alfreton furnace, and those of Levi and Schmidt on charcoal-furnaces, gave some indications, which might, if followed out, have led to important results. The laborious nature of the investigation, and the difficulties attending it, appear to have checked all further inquiry. We know, consequently, but little of the *rationale* of the smelting process, which may be briefly stated to be as follows :—

The gases formed during the operations going forward in the white hot mass—carbonic oxide, and much volatile combustible matter—very complicated in its constitution, ascend at a high temperature. As the ore is supplied to the furnace, it meets those powerful reducing agents, and a portion of the oxide of iron is reduced to the metallic state. Combination also takes place between the iron and the silica and alumina present in the ore. The chemical affinities of the lime-flux then come into play. Silicates of lime and alumina are formed, and the slag thus produced contains but little iron ; the metal being liberated probably in the condition of pure or malleable iron. This descends further in the furnace, and, at the high temperature which there exists, it becomes liquid, combining with the carbon to form carburet of iron. Still descending through the material, there is no doubt but silicon and other alkaline metals combine with and materially influence the character of the iron. The cast iron obtained is very variable in its composition; it must, however, be regarded as a compound of iron and carbon, about four equivalents of the former to one of the latter, or, iron 94·9, carbon 5·1. When all this has been effected, immense volumes of gases intensely heated escape. These were formerly absolute *waste*. They are now collected, and carried, by means of pipes, to other furnaces, where, under favourable conditions, they can be made to produce a temperature varying from 3,210° Fahr. to 3,632° Fahr. It is stated on good authority that the saving of fuel with two furnaces making 240 tons of iron per week, by applying the waste gases to the blast-engine and hot-air stoves, has been £1,200 a year!

Such are the advances which have been made in the manipulatory details of iron manufacture, by which we are enabled to make cheaper iron than any other country in the world. With the chief varieties of cast iron, viz., *dark grey*, *bright grey*,

mottled and *white*, we are well acquainted, and a good furnace-manager can determine, from known materials, the result which shall be obtained. With all the mysteries of *cinder-iron* we are also familiar; and it cannot but be regretted that there are manufacturers who study the art of sophistication so zealously as to produce a composition, still called iron, in which that metal occupies the minimum space.

We started with the assertion that although iron had been so long known to mankind, we were still imperfectly acquainted with its physical and its chemical properties. We repeat this, and cannot refrain from expressing a hope, seeing that the experiments required would be too expensive for any man to undertake, that some associated iron-masters would select a skilful and reliable experimentalist, place a furnace at his disposal, and meet all the expenses of this fine inquiry.

Crude pig-iron is a compound of iron and carbon, mixed with several substances. To produce wrought or malleable iron, a large portion of the carbon is to be removed, and the impurities dissipated. The process is essentially one of oxidation. It is not possible to describe in detail the structure of the "refinery," or oxidizing blast-hearth, nor to enter into the history of the process of "puddling," and discuss the several stages of the operation. It must suffice that we state, that the refining consists in placing about two tons of pig-iron upon a fire, lit in the centre of the refinery-hearth, covering it up with coke, and then urging the fire by a gradually-increasing blast until the iron is melted. It is kept in a perfectly liquid state under the influence of the blast for some time, the carbon combines with oxygen, and escapes as carbonic acid, while the adventitious metals are oxidized and volatilized. In the Welsh iron-works one ton of white iron takes from one hour and three quarters to two hours to refine, the consumption of coke being from six to eight cwt., and the loss of metal about three cwt. Instead of air, steam is often employed in the refinery process, and in general with the best possible result. In effect, the process is to blow the fire on the hearth, and act on the melted iron, with steam under a pressure of from 40 to 50 lb., and at a temperature of about 700° Fahr. We are informed that 396 cwt. of pig-iron produces by this process 393 cwt. of refined metal. The saving here is great, and half an hour appears a sufficient period for refining a ton of crude pig-iron. Refining by gas has been introduced, and by some highly approved.• The *fine metal* produced by the refining process is subjected to the process of "puddling," introduced in 1783 by Mr. Henry Cort. The puddling furnace is so constructed that the intensely-heated vapour or flame plays or reverberates upon the melted metal, and being brought to a bright red heat, about four or five cwt. of find metal

is introduced, together with some rich scoriæ or forge-cinders (scale oxide of iron). By the heat applied, the iron is melted, and the workman stirs it about with his poker so as to expose every part to the flame. The carbon is burnt off; the metal becomes less and less fusible, passes into a thick and tenacious state, so that it sticks together. The "puddler" now forms the iron into balls called "blooms." Each bloom is removed with a pair of tongs; it is compressed into a cylindrical form by a few blows from a heavy hammer, and then converted into a bar by passing it between grooved rollers. This is malleable iron, which is fibrous in its structure, and although the purest commercial form of the metal, it still contains about one half per cent. of carbon, with traces of silicon and other metals. The process of boiling iron, by which crude metal is converted into the malleable form without the intervention of the "refinery," is another mode of proceeding leading to the same end.

The Bessemer process has excited considerable attention, and it must be admitted to be a highly scientific one. Air is forced through a mass of fluid iron, the oxygen of which, acting on the red-hot metal, greatly increases the heat. The carbon, converted into carbonic oxide, burns off in a blue flame, the whole mass being in a state of violent ebullition, and the impurities are thrown up, as oxidized slag, in the form of froth. Mr. Bessemer says, "One of the most important facts connected with this new system of manufacturing, is, that all the iron so prepared will be of that quality known as *charcoal-iron*, because the whole of the processes being conducted without the use of mineral fuel, the iron will be free from those injurious properties which that description of fuel never fails to impart to iron that is brought under its influence." At that stage of the process immediately following the "boil," the whole of the crude iron has passed into the condition of *cast* steel of ordinary quality. By the continuation of the process, the steel so produced gradually loses it small remaining portion of carbon, and passes successively from *hard* to *soft steel*, from *soft steel* to *steely iron*, and eventually to very soft iron; *hence at a certain period of the process, any quality of metal can be obtained.* Something more than the inventor states certainly takes place. In these days of Mechanics' Institutions, every person has seen the beautiful experiment of burning steel wire in oxygen gas. This experiment is entirely eclipsed by the brilliant display of sparks from the boiling iron undergoing the Bessemer process. Much iron is burnt off, and from the experiments made at Dowlais and at Briton-ferry, we learn that there was obtained "a mere mass of red-hot friable matter; which, from its crumbling and non-cohesion, was with difficulty formed into an ingot."

Experience seems to have modified the conditions. All varieties of iron are not advantageously treated by the Bessemer process; but some varieties, such as the Swedish irons and some of the very best British pigs, are now being converted into that valuable metal, existing in a state between iron and steel, employed for plating those ships of war which are to withstand the hammer-headed shots projected from an Armstrong gun. From a metal similar to this are made those remarkable pieces of Ordnance manufactured by Whitworth. There appears to be a stage in the process of converting iron when we have all the qualities of the best steel, combined with the valuable properties of malleable iron. This condition is arrived at by another process. Articles of various kinds, such as screws, pulleys, &c., requiring great toughness, are cast from the ordinary selected pig. In this state they are very hard, and consequently very brittle. These articles are placed in a furnace with a quantfty of hematite iron ore, and the whole exposed for some time to a moderately high temperature. The peroxide of iron, under the action of heat, removes a certain portion of the carbon, and exceeding toughness results from the operation. Stirrups, bits, spurs, and much saddlers' ironmongery, are now made by this process. Although this operation has in many respects the character of annealing, yet it is something more. It is quite certain that a molecular change takes place by the long-continued action of heat alone; beyond this, however, the presence of the peroxide of iron determines by chemical action the constitution of the metal. Very fine castings, many of them copies of examples of high art, are made by this process. A very liquid metal is obtained to secure the requisite sharpness. This would be brittle when cold; but by the combined action of heat and hematite, the requisite toughness is secured.

Before leaving this portion of our subject, the Berlin iron-castings claim some attention. Dumas has stated that these remarkably delicate productions are due to the presence of phosphorus and arsenic in the iron from which they are cast. These substances certainly have a tendency to give great fluidity to the melted iron, and fluidity is essential to the production of such filigree-work as we see in the elaborate bracelets, neck-chains, brooches, and fans which many of the Berlin foundries produce.

The reputed origin of this manufacture is interesting. At the time when the final struggle commenced between Prussia and Napoleon, the patriotism of the Prussian ladies was particularly conspicuous. They sent their jewels and trinkets to the Royal Treasury to assist in furnishing funds for the expenses of the campaign. Rings, crosses, and other ornaments in cast-iron

were given in return to all who made this sacrifice. These gifts bore the inscription, "*Gold von Eisen;*" and these Spartan ornaments are to this day much treasured by the possessors in their families. The demand arising from these circumstances led to that wonderful delicacy so much admired.

Notwithstanding the statement made by Dumas, we have been assured by a Prussian founder that the Berlin castings are largely made from English iron, and that the whole secret of the manufacture consists in securing the necessary fluidity of the melted metal by a very high temperature. A fine silicious sand is required to form the moulds, and this, Ehrenberg informs us, is entirely composed of the shells of microscopic animalcules, which once swarmed in the ancient seas that united the Baltic with the Black Sea.

Where chains are produced in Berlin iron, the central rosette of each link is the only portion really cast, the loops forming the connection being of wire bent to form, and laid into the prints provided for them in the mould. This being arranged, the metal to form the rosette is run in, fills the impression of it, and surrounds the ends of the iron rings; thus forming the link. We have, however, had in our possession a chain made by a German workman, at the Hayle foundry in Cornwall, which was nearly five feet in length, consisted of 180 links, and weighed about an ounce and a half, the whole of which was cast. It is curious to contrast these delicate castings, weighing but a few grains, with such enormous castings, as the cylinder of the hydraulic press which was used to raise the Britannia tube into its place, and to push the *Great Eastern* to her home on waters;—the weight of which was twenty-two tons.

We must pass on to Steel. It has been shown that pig or cast iron is a compound of iron and carbon. The malleable iron is produced by depriving the metal of much, but not all, of its carbon; and we have now to show that steel is another compound of these two elementary bodies. If we place together the chemical constituents of each of those states of iron, the peculiarities will be at once evident.

	CARBON.	IRON.
Pig Iron	5·1	94·9
Malleable Iron	0·25	99·75
Shear Steel	1·5	98·5
Cast Steel	2·0	98·0
Indian Steel (*Wootz*)	7·18	92·82

In India, and in some of the Continental States, especially in Westphalia, Styria, Siegen, and in Sweden, steel is prepared directly from the ores of iron, and is known as native steel. In these places, charcoal is employed as the fuel; but certain manipulatory details, into which we cannot at present enter,

must be closely attended to. In Germany, a puddled steel, which is much in request, is prepared by a process analogous to the puddling of iron; the only difference being, that as soon as sufficient quantity of the carbon has been removed, the access of air is prevented, and the carbonized metal is retained, without change, in a molten state for working. This puddled steel is not so much used for cutting-instruments, as for the steel ornaments, and fancy articles which the Germans produce so largely, and for steel axles, winches, tires, &c.

The India *wootz* is prepared from a very rich magnetic oxide of iron, by a rude process, differing indeed in no respect from that which the natives of India employed when Alexander marched into Asia with his conquering army. In the first place, a cake of brittle grey iron is produced, with considerable waste in the slag. Cakes are carefully selected, annealed for several hours in small charcoal furnaces, finally carefully re-melted, and cast into ingots. The finest ingots are taken and drawn out by a hammer of a few pounds' weight. Thus the finest Indian sword-blades are manufactured. Damascus steel, which is principally worked up into sword-blades, consists of a more highly carburetted steel than any European manufacture; and the peculiar characteristic Damascened patterns which appear on the steel, are due to a skilful cooling, by which a division is effected between two carburets of iron. The wonderful temper of the Indian and Damascus blades, which has been almost the despair of European cutlers, is due to the regulated temperature at which the blade is worked. If this be too high, the metal flies to pieces; if too low, it becomes hard and inflexible. The Indian steel has been cleverly imitated by combining nickel, manganese, and tungsten with the iron, and also by welding together plates of iron and steel. None of these imitations, however, possess all the peculiarities of the Damascus steel.

Steel differs from wrought iron in possessing the remarkable property of becoming intensely hard, if, after having been made red hot, it is plunged into cold water. If the metal has been brought up to a melting heat, and then suddenly cooled, such an arrangement of the particles takes place as to give the steel a hardness sufficient to scratch glass. By the process known as "tempering," almost any degree of softness can be obtained. In the entire range of metallurgy, there is no operation more deserving attentive study than this. The surface of the steel is polished, and it is exposed to heat. As the heat is increased, there is a curious and uniform change in the colour of the surface. The first visible tinge of yellow increases the toughness without diminishing the hardness; a deep yellow or orange indicates that the condition is that which is fitted for razors or

penknives; a yet deeper orange is required for table cutlery and joiners' edge-tools; and a blue for watch-springs. These colours have been referred to oxidation; but it is by no means satisfactorily shown that they are not due to a molecular arrangement, quite independent of any chemical change.

Our process of preparing this useful metal is, to subject selected iron—usually Russian or Swedish—in contact with small pieces of wood-charcoal, in closed vessels, to a very high temperature, for some time, with a total exclusion of air. Different kinds of iron produce steels of different characters; therefore the persons who possess this knowledge are enabled to prepare steel fitted for any required purpose. The Bessemer process has been employed with considerable success in the manufacture of steel. One advantage is, that the decarbonization of the iron can be regulated with great accuracy. A given amount of air passed through the incandescent iron, produces a known result, and this is registered by a dial. This process has advanced but slowly in England; in Sweden, it has been extensively employed. Large steel circular-saw-plates have been made by Mr. Göranson, the ingot being cast direct from the fluid metal, within fifteen minutes of its leaving the furnace. At Bordeaux furnaces are at work especially on this principle; and at Liége, from the native coke-iron, beautiful steel is made by the application of the discovery of Mr. Bessemer. At Sheffield, however, not only at the inventor's works, but in some other large establishments, the process of blowing air through the molten iron to produce malleable iron and steel is now in use.

All that has been attempted in this sketch is to give a sufficiently intelligible description of the processes by which our iron ores are converted into those metals which are so important to our manufacture and commerce, our main purpose being to indicate the large field of inquiry which is yet open to any zealous investigator. The iron ores of the United Kingdom have been analyzed with the most scupulous care. These analyses, published in the "Memoirs of the Geological Survey," may be regarded as the first step in the larger inquiry. Within the last year, considerable attention has been directed to the phenomena of steel manufacture, from the publication of the investigations of M. Fremy. In his researches, this eminent chemist has arrived at the conclusion, pointed to previously by M. Despretz, that nitrogen exercises an important influence over the phenomena of steeling, and that carbon plays a less necessary part. M. H. Caron, M. H. St. Claire Deville, and others, differ from M. Fremy, and still refer the formation of steel to the chemical combination of the iron with carbon.

Iron ore is raised from the earth at a cost of three or four shillings the ton. After an outlay of thousands in the building

of furnaces and the construction of the necessary works,—and after all the cost of fuel, flux, and labour, iron is made at less than £3 the ton. By every movement this price is, of course, considerably increased, and by certain processes of manufacture it is augmented in a remarkable manner. The best iron, for example, costs rather more than 3*d.* per pound, and out of this, 50,000 hair pendulum-springs for watches can be made, at 2*d.* each; thus raising the value of the pound-weight of iron to upwards of £400! The skilled labour of the ornamental iron-caster so increases the value of the crude grey iron, in the manufacture of articles of use and ornament, that it reaches, in many cases, to ten thousand times the original cost of the material. These curiosities of manufacture,—upon which an interesting essay might be written,—represent the value of man's creative power in rendering the productions of nature the means for improving the condition of the human race. They are the outward and visible signs of the moulding power of the mind of man; and although we are forbidden to worship the work of a mortal, yet a due appreciation of his handiwork leads to a more perfect understanding of that Immortal Power, from whom creation springs. The Britannia Tube, the Tamar Bridge, the Crumlin Viaduct, the Suspension-bridge of the Menai Straits, or the High-Level Bridge across the Tyne, are the works of Titanic minds, and as such, they possess the power of elevating every human being who looks on those examples of engineering skill. The *Great Eastern*, the *Warrior*, and the *Black Prince*, are evidences of power, which morally give strength to the men of the country to which they belong. The thousands of miles of iron bars which are laid over our Island do more than enable us to pass with celerity from place to place. They are breaking down the barriers of prejudice, they are destroying the walls which separated the town and the country; and both are gainers thereby.

Man begins to ascend towards Heaven, the moment he seriously exerts his mental gifts. The breath of life which was given to him by his Creator, was an influence of a far more exalted character than any of the Physical Forces, which are so terrible in action, but which are subjugated to human will. By the might of mind, man takes the dust of the earth, and he seizes the spirits of the air; he brings one to act in force upon the other, and the result is a *creation* for good! What Teutonic god, what Oriental Enchanter, ever performed so vast a work as that of rearing across a strait of the sea, a tube to endure for ages the rushing to and fro of a Behemoth of man's creation, whose "bones are as strong pieces of brass; his bones are like bars of iron,"—which draws after him in safety hosts of men? What Celtic Sprite ever fabricated from the crude masses of "the

earth's foundations," so fine a film as that which man has spun in the hair-springs that mark the tread of time? or wove from such coarse materials so delicate a tissue, as those iron ornaments which hang around the neck of beauty? "Iron is taken out of the earth, and brass is molten out of the stone." The promethean power which made man a metallurgist, advanced him as an intellectual creature, and every step we take in subduing nature, according to God's command, elevates the whole human race another degree above the Earthiness of this existence.

ARTIFICIAL LIGHT.

BY D. T. ANSTEAD, M.A., F.R.S.

UP to the close of the last century the best contrivances in use for obtaining artificial light were limited to oil lamps of very imperfect and uneconomical construction, and candles of wax and tallow. Blazing torches of pine, ends of rope soaked with tar, and occasional bonfires of tar-barrels, might serve for special occasions, but could hardly be looked upon as available for ordinary purposes, and other better contrivances were unknown. In warm countries, where tolerably pure vegetable oils are easily and cheaply obtained, where the winter nights are not very long, and where, therefore, little artificial light is needed, a piece of twisted cotton or yarn partly resting in a saucer of oil serves all purposes. Lamps of the most elegant form, but of this very simple construction, were in all former times, and are still, used by all classes in Greece and Italy. Such lamps date back to the remotest antiquity, and a sea-shell has no doubt served as their original model. The jar of oil on a shelf always at hand serves indifferently for feeding the lamp and for cooking, and indeed many travellers have recorded, though by no means with satisfaction, that they have seen the very lamp itself, burning in the chimney, taken down from its place in order that a part of its rich contents might be poured out to assist in some savoury fry going on below.

In cooler climates, where the winter nights are much longer and where oil readily congeals, lamps were long ago replaced by candles. At first rushes, and afterwards cotton wicks, were dipped in hard animal fat or tallow in a molten state, and when cool were ready for use. A better kind of candle was made after a time, by pouring purified tallow into *moulds* in which twisted wicks were previously fixed; and hence the division of tallow candles into moulds and dips. Both required constant snuffing, and if long neglected were dangerous, owing to the unburnt carbon which collected at the top of the wick, and at last fell off in a state of red-heat.

Candles manufactured from beeswax, purified and bleached by long exposure to the sun and by some chemical processes, served as an admirable but very costly substitute for tallow; but no large quantity could ever have been obtained, and they could never enter into general use.

The sixty years that have passed since the beginning of this century have witnessed marvellous improvements in almost every article of domestic use, and so much has been added to the stock of common comforts, rendering many of the luxuries of former times quite indispensable, that the habits and tastes of all classes have become affected to an extent little thought of. In this matter of illumination a return to the former condition would involve so complete a subversion of our established customs as to be almost impossible; and this will be evident when we briefly describe the existing sources of artificial light and the present condition of manufacture in respect to them.

Candles are still used to an enormous extent: fifty thousand tons weight of tallow have been entered for home consumption in England each year during the last quarter of a century; but candles, originally made of tallow alone, although still manufactured of unpurified tallow, are to a great extent becoming replaced by those composed of a substance derived from various animal and vegetable oils. But while the consumption of tallow has remained nearly stationary, the population itself, and the quantity of artificial light of all kinds consumed by each family have been increasing with great rapidity. Wax, like tallow, has continued to be imported, and is still used as before; and another curious substance—spermaceti—long since made into candles, has never been a common material. Unimproved lamps for burning common oils are also still in very extensive use; but, in addition to all these, many new sources of artificial light have been discovered; one of which, more than all others, has helped to turn night into day. We allude, of course, to the common coal gas, which is not only obtained at once by simple distillation from coal, but the manufacture of which has led to so many and such extraordinary results of other kinds, that it might well be regarded as one of the greatest and most useful discoveries of modern times.

The contrivances now commonly adopted for obtaining artificial light may be grouped under the following heads:—*First*, There are tallow candles, which are still largely employed. *Secondly*, Stearine, or composite; and, more recently, paraffine candles, which will ultimately, no doubt, replace tallow in domestic use. *Thirdly*, Wax, and Spermaceti candles, scarcely altered from their old construction, and which continue to be used for certain purposes, although the consumption is not increasing. *Fourthly*, Animal and vegetable oils used in lamps, either of the old kind or of improved construction. *Fifthly*, Certain mineral oils, such as naphtha, paraffine, and other similar substances, used also in lamps, and replacing oil to some extent. *Sixthly*, Coal gas, obtained by the destructive distillation of all

the varieties of coal; and oil gas, obtained by the distillation of oils. There are also two contrivances, one involving combustion in an oxygen atmosphere, and the other making use of the electric spark, which are both remarkable for the intensity of the light produced, but which are at present too costly and unmanageable to enter into general use.

Tallow candles have so unpleasant an odour, they are so apt to gutter or melt more rapidly than the wick can consume the tallow, they so generally smoke and choke the wick and require its constant removal by snuffers, and are so little economical in the most important sense of the term, that they will probably ultimately disappear from use. They are, however, sold at so low a price, and possess so many apparent conveniences, that among the lower classes they must long retain their hold.

The first improvement in the material used for candles dates as far back as 1799, when a person named William Bolts took out a patent by which he proposed to squeeze the tallow after melting, and while in the act of cooling from a melted state. The result of this squeezing would be to separate the tallow in some measure into its component parts; for, although it was not then known, chemists have since discovered that most animal and vegetable fats and oils are composed of at least two distinct solid bodies, one liquid oily substance, and one syrupy substance. Of all these, one only of the solid bodies is that which is really valuable for illuminating purposes. It is called *stearine*, and is the really valuable material in the candle. The syrupy substance above alluded to is now familiarly known and extensively used under the name *glycerine*, and, as the reader may easily satisfy himself, it gives hardly any light when burnt with a wick. The effect of squeezing melted tallow is to remove a large part of this peculiar substance. The same process was afterwards effected much more completely by chemical action, and is now managed by blowing steam at a high temperature through the melted fat or natural oil.

A series of brilliant experiments by two eminent French chemists, Chevreuil and Gay-Lussac, had so long ago as in 1825 cleared up the whole subject of the composition of fatty matters, their relative value for illumination, and the various methods by which their decomposition could be effected on a large scale; but it is only within a very few years that it has been found possible to practise these methods economically, and separate the *stearine*, which is the material best adapted for making candles, from the other solid contents of tallow and from a peculiar thick oil, which is very valuable for lubricating machinery, and may also be used for burning.

Some of the vegetable oils, especially those from various species of the palm-tree, are now extensively used in the manu-

facture of composite candles. For this purpose the fatty acids of one kind of palm require to be mixed with stearine obtained from another kind of palm oil.

The annoyance of having to snuff candles has been removed by plaiting and twisting the wicks after dipping the cotton in a solution of borax. The way in which this contrivance acts is simple enough. It depends on the fact that flame is a mere shell. Owing to there being no supply of oxygen gas within, a charring of the wick there takes place, as a natural consequence of exposure to the heat, but the carbon remains. When, however, the cotton has been previously twisted, the tension of the threads obliges the wick to curl outwards towards the shell of flame, where it becomes completely burned, while the earthy impurities of the cotton form a glass with the borax, and are thus got rid of without mixing with the fatty acids, which are apt to splutter if not protected in this manner.*

Candles made of the stearine of any common fat, whether animal or vegetable, can now be prepared so as to imitate and almost rival wax and spermaceti. The latter substance may ultimately be superseded altogether by chemical contrivances; but it is not likely that wax will ever be excluded from our drawing-rooms. The bleaching of wax and its preparation for use in candles have scarcely been altered or simplified, except by some trifling change introduced in the structure of the wick. The material which will ultimately take the place of wax is paraffine, already largely used, but not yet cheap enough to command the market.

Oil lamps have improved marvellously of late years. The ingenious contrivance bearing the name of its French inventor, M. Carcel, was a great step in the right direction. In this lamp the oil is raised by clock-work, so as continually to overflow at the bottom of the burning wick, which is thus never charred. The wick is circular, and a powerful draught of air is made to pass both within and without it by the use of a high glass chimney. Almost any kind of oil burns in it with great splendour, and for a long time without altering the wick. In this, and a number of contrivances known by different names, the principle involved is that of producing as nearly perfect combustion as possible of the oil by carrying a column of air rapidly in the interior of a thin circular sheet of flame. In carrying out the principle thus enunciated, a great and important stride was made towards a good cheap light, and most of the modern alterations have been mere adaptations, applied with more or less ingenuity and taste.

* See "Faraday's Chemical History of a Candle," mentioned in our List of Books.

The *moderator* is another form of lamp now in very common use. It involves two or three important principles, one consisting of a powerful spring, whose force is equal to from fifteen to twenty pounds, which presses on a disk and forces the oil up a tube, whence it flows over the burning wick, which is thus always saturated, as in the Carcel lamp. To prevent the oil, however, from flowing over too rapidly, there is placed in the tube an ingenious regulator, or *moderator*, of a tapering shape, which is so contrived as to check and diminish the flow of oil in proportion as the pressure is increased, always allowing sufficient oil to pass to feed the lamp when burning. The oil being thus supplied with perfect regularity, just saturates a hollow circular wick, through the middle of which a current of air is constantly drawn by means of a glass chimney. A number of small contrivances introduced by Argand, the inventor of the circular burner, have brought it to a state of extreme perfection.

Common vegetable oils can be burned with advantage in lamps where the current of air is strong and where care is taken that the top of the wick is kept smooth; but all these oils are costly, and the quantity of smoke that arises from the unconsumed fuel is extremely disagreeable. Animal oils are not generally used, owing to the smell they emit when burning.

Mineral oils are now entering into large consumption, and of these the recently-introduced *paraffine oil* is one of the most remarkable. It will be necessary to consider a little the nature and preparation of this curious substance, if we would fully understand the very great change that has taken place of late years with regard to the methods of obtaining artificial light.

Paraffine, though only recently manufactured in sufficient quantity to be used practically, has been long since known as one of the products derived from a peculiar destructive distillation of vegetable matter, whether in the state of wood, peat, or coal. Various bituminous shales and other mineral deposits that abound in some parts of the world, also yield the same substance. It is obtained by carrying on the distillation in a retort kept at a low red-heat, the products being received and condensed at a temperature of about 55° Fahr. in a very carefully-contrived apparatus. A light oil is the principal result of this operation, and this oil, after being purified and redistilled, is found to be a fluid compound, containing a certain proportion of paraffine oil, which greatly resembles clear transparent naphtha, a somewhat heavier oil, also used for burning, a lubricating oil, and solid paraffine. The light oils yield an intense white light, admirably adapted for general use.

In order to obtain a clear smokeless flame from paraffine oil, it is necessary to take some precautions. Owing to the capillary action of the cotton used as a wick, the fluid oil may be

kept at some distance from the flame, so that only the vapour in a heated state is ignited. What actually burns is thus a gas obtained from the paraffine oil by the application of moderate heat.

Many other naphthas (camphine among the number) have from time to time been introduced and tried in lamps; but it is only lately that any satisfactory result has been obtained. A disagreeable odour, not belonging to paraffine itself, and probably not essential to the oil, still characterizes the naphthas commonly prepared and sold; but this can be removed by certain processes of purification, and it may be expected that the consumption of paraffine oil will greatly increase. The paraffine oils have this great advantage over turpentine, and other light oils obtained in a similar way, that they do not burn when exposed directly to flame, and they do not soil linen or adhere to the fingers.

Pure paraffine is itself a soft light solid, without taste or odour, melting at a temperature little above that of the blood (112° Fahr.), and burning with a clear white flame, without smoke or ash. It has already been made into very beautiful candles; but the manufacture at present has not attained great importance, although as much as 300 tons were employed in this way two years ago. The cost of obtaining pure paraffine is the present cause of this delay in the progress of the manufacture.

The minerals which yield paraffine oil on exposure to a low heat in a retort will yield to destructive distillation at a higher temperature a very large quantity of gas (chiefly carburetted hydrogen), which takes fire readily on exposure to flame; but those best adapted for the one purpose are least fitted for the other. Bituminous shales are best for paraffine oil, and coal for the manufacture of gas. The gas thus obtained, when freed from certain impurities, burns with an intense and nearly pure light, and is the common gas supplied for burning.

So long ago as in the year 1659, and again about eighty years afterwards, gas of this kind, issuing naturally from the ground in the neighbourhood of coal-mines, had been the subject of experiments of a scientific nature, which were communicated to the Royal Society, but no practical result was obtained till in 1792 Mr. Murdoch lighted his own house with a similar gas, and was shortly afterwards successful in lighting in the same way the factory of Messrs. Boulton & Watt at Soho. It was not till 1813 that any important step in lighting towns on a large scale was made, but from that period to the present day the consumption of gas for purposes of illumination has been increasing with such enormous strides that scarcely a town in the civilized world is now unsupplied with this admirable and useful means of turning night into day.

Coal is by no means the only, though it is certainly the principal, material from which gas is obtained. Bituminous shales, oil, resin, peat, and wood, are all capable of yielding a certain supply; and some of these substances, badly adapted for fuel, are extremely valuable for illuminating purposes, owing to the large quantity of light carburetted hydrogen gas that may be obtained from them. The presence of this gas in the actual pores of coal, whence it is given off in large quantities, is often intimated underground by a peculiar singing noise, and in some mines a naked light applied to freshly-cut coal will actually produce a flame from numerous small jets. This is probably owing to the great pressure brought to bear upon the remainder, when part of the coal is removed. A very much larger quantity of the same gas is obtained afterwards, by exposing the coal to intense heat in a retort, arranged so that the products of distillation shall be received in convenient vessels for the purification of the gas, and afterwards transmitting it by pipes to the place where it is required for burning.

Although, however, the process of obtaining gas that can be rendered useful for illumination is so simple, that every schoolboy has made the experiment in the bowl of a tobacco-pipe, the mechanical difficulties of applying it on a large scale were at first exceedingly great, and have only lately been overcome in a satisfactory way. All the gaseous substances that are obtained from the combustion of the coal are by no means fit for burning, as they include, besides the gas we use in our streets and houses, several other gases, more or less noxious and useless, and many vapours which require to be separated. Besides these, there are fluid, semi-fluid, and solid products either carried over or left behind. Even the illuminating gases themselves are many in number, and vary in their properties, some having a disagreeable odour, some being unwholesome and therefore objectionable for general use, and others exceedingly valuable as giving pure white light without adding to the heat of the mixture during combustion. The essential ingredients of illuminating gas are carbon and hydrogen; but all true coal contains, besides these, both oxygen and nitrogen gas and sulphur. These elements, either alone or in various new combinations, are obtained after rapid distillation at high temperature, so that watery vapour, ammonia, sulphuretted hydrogen, carbonate of ammonia, and a variety of compounds, of which paraffine and benzole are the best known, come off with the illuminating gas, and may be collected. They are present in quantities that vary according to the nature of the coal, the temperature employed in distilling, and the length of time occupied in the manufacture.

Not only, therefore, is there left behind in the retort a

certain quantity of coke, consisting of the carbon that has not combined with oxygen and hydrogen, mixed with the earthy impurities of the coal; but by various processes several liquid and solid substances, of more or less utility, become condensed on the other side, before the gases are entirely set free. The gases intended for burning require to be purified, so as to get rid more especially of the sulphur compounds and carbonic acid, an operation in which slaked lime is especially useful, as it absorbs large quantities of the most objectionable substances.

The gas being set free in a tolerably pure state, yields, within certain definite limits, a quantity of light greater in proportion to the carbon it contains. For this purpose, the poor and rich gases require to be mixed, the pure light carburetted hydrogen giving very little light at the ordinary temperature at which combustion is effected, and gases with too much carbon giving off smoke while burning. The mixture being made, the maximum light is obtained by a nice arrangement of the quantity of gas allowed to escape, and the draught of air admitted or forced to pass through the flame.

It is unnecessary to describe the ordinary contrivances used as gas-burners, although some of them are much more ingenious than others, and better adapted to give light. On a large scale, however, and in public buildings, the method of lighting that is adopted has such enormous influence on the health and comfort of those exposed to the atmosphere of the place, that it becomes a matter of the most serious consideration.

There cannot be a doubt that a large proportion of the headaches, sleepiness, and general discomfort felt in public buildings lighted with gas, where no special means are adopted for removing the products of combustion, are due to the accumulation of carbonic acid and other poisonous gases given off during combustion. While gas is burning, it removes from the atmosphere a large quantity of oxygen; and as this is also the result of breathing, the effect is soon felt where a large number of human beings are together. There is but one way of removing this great evil, but fortunately that method is fully adequate. It consists in the use of a ventilating burner, either resembling in its principles of action the burner originally contrived by Faraday, or of a still more simple arrangement, the whole of the jets being connected with an air-chamber and chimney, so placed that the draught carries off at once into the open air every particle of matter produced during combustion. Faraday's burner is an ordinary argand burner, of large size, with a chimney, surrounded by a wider and taller chimney, closed at the top, and opening at the bottom into another tube, that carries away the products of combustion. The star method of illumination involves the use of numerous groups of small jets

arranged concentrically, each group being arranged in the form of a star, and the whole forming a brilliant and steady volume of light. This latter is, beyond all comparison, the most pleasant and the brightest light that has yet been obtained artificially. It requires, however, a chamber and large chimney communicating directly with the outer air, and must be placed at the ceiling or roof of the room to be lighted. It is comparatively expensive, consuming a large quantity of gas compared with the available light yielded, and is thus little adapted for general use where economy is considered.

The quantity of good illuminating gas procured from a ton of coal varies greatly according to the nature of the coal and the method of manufacture. By the old process, the yield of gas rarely exceeded 10,000 cubic feet per ton of coal, except from some Cannel coals, especially rich in hydrogen; whereas, by what is called White's process, as much as 30,000 cubic feet have been obtained from ordinary kinds, and 50,000 from Boghead coal. The illuminating power of the gas made has also been increased by modern improvements, the increase amounting to from twelve to upwards of a hundred per cent. on the old method, according to the nature of the coal.

To give an idea of the value of the improvement in artificial light by the introduction of gas, we must enter into some small calculations. Taking sperm candles as the unit (each candle burning ten hours, at the rate of 120 grains per hour, and the value being about 4*d.*), the quantity of ordinary coal required to produce light equal to 1,000 such candles (value £16. 13*s.* 4*d.*), according to the old method of making gas, varied from four to seven hundredweight; while, if Cannel coal were used, about half that weight would be needed. At present, however, the consumption of coal for this quantity of gas would not exceed from 350 to 400 pounds of ordinary kinds; and of Cannel, from 105 to 160. With this quantity of coal (value about three shillings in London) from two to three thousand cubic feet of gas are manufactured; so that, under any circumstances, the cost of gas-light, compared with that of sperm candles, is not more than one-fiftieth part. In point of fact, however, with the methods of manufacture now adopted, and the increased illuminating power of the gas, it is estimated that the actual cost of 1,000 feet of gas of the best quality is little more than one shilling; so that artificial light really costs not more than one-hundredth part of the price that it did fifty years ago.

In countries where coal is scarce and dear, wood, peat, and brown-coal all yield, on distillation at very high temperatures, certain illuminating gases, which can be purified for burning, and thus rendered available for general use. It is only very lately that a method of doing this has been adopted with

success; but it is said that wood and peat gas are already used with great advantage in many German and Swiss towns.

In addition to the contrivances adopted for obtaining artificial light already alluded to, and in common use throughout the civilized world, there are two others occasionally employed, although not yet produced on such a scale and at such a cost as to be economically important. One of these is merely a modification of ordinary gas-light, involving the use of pure oxygen gas, instead of atmospheric air, as the agent of combustion, and introducing a solid incandescent body such as lime, to increase the intensity of the illuminating power. The other is the electric light, obtained by bringing into close proximity, without actual contact, two pencils of charcoal, and passing between them a powerful voltaic current. Great difficulty has been experienced in rendering light thus obtained sufficiently steady for any practical purposes, and these difficulties are not yet fully overcome, although a partial success has been obtained in Paris, by methods more simple and less costly than those before used.

And now, in bringing to a close this account of Modern Illumination, let us consider for a moment how far and in what way we are benefited by artificial light, rendered cheap and abundant by so many ingenious contrivances.

Half a century ago, all the great capitals of Europe, although then not half their present size, were dangerous residences to their honest inhabitants, and unmanageable in regard to police supervision, owing to the difficulty of obtaining sufficient artificial light during the long dark nights of winter. The growth of population that has since taken place, and the development of the resources of our own and other countries, would probably have been impossible, without the discovery and rapid introduction of some means of economically and effectually lighting the streets and alleys, which had long served as the haunts of thieves and dangerous characters of all kinds. It is not too much to say that, in this matter alone, the introduction of artificial light has been the main agent employed in effecting a social improvement, compared with which all others are secondary. The millions of cubic feet of gas now burnt nightly in our streets are, beyond comparison, the best, the most permanent, and the least expensive source of security that could have been introduced, and have served, more than anything else, to check those deeds of wrong and violence that darkness cannot fail to shelter, and invariably fosters.

Nor are we less indebted to gas for lighting our public buildings of all kinds. Here, again, the necessity for increased light has enforced a consumption of material which, as far as we can see, no natural supply of oil and tallow could ever have

satisfied. Of all these matters the supply, however large, is limited and costly, the cost increasing rapidly as the consumption becomes greater. The gradual but steady improvement in the quality and purity, and the great reduction in the cost, of gas has been met by a corresponding increase in the quantity used.

When so much better and cheaper a light than candles or oil lamps was first introduced and found so useful, it became almost inevitable that the old sources of artificial light should also be improved. Thus candles, as we have said, are now of greatly improved quality; they are made from various materials, formerly thought altogether inapplicable; the best of the present day are hardly more expensive than the worst of half a century ago; while in all important respects, the very materials that rendered the tallow candles of former times a nuisance to everybody, being now separated and applied to their proper uses, are found to possess a value positively greater than that of the combustible material itself, which they at one time interfered with and injured.

The scientific principles of consuming fuel so as to obtain light being also now better understood, there is far less waste than before in our lamps, and some of them are models of mechanical art, obtaining the most perfect result at the smallest expenditure of material. In all these matters the mechanical improvements and the application of chemical principles have gone hand in hand.

It is altogether impossible to exaggerate the value and importance of light; and it is certain that everything done to facilitate the means of obtaining and distributing artificial light cannot fail to be of general benefit to mankind. And if, looking at the glorious orb of day, and remembering all its life-giving properties, we exclaim with the poet—

> "Hail! holy light—offspring of Heaven first born,"

we may, with equal propriety, regard in artificial light, however obtained, a younger, but hardly less useful and important creation, always at hand, requiring a certain development of human intelligence to render it available, but rewarding us by communicating a means of moral and intellectual light, as well as that physical illumination that is so useful and so indispensable.

THE BREATH OF LIFE.

BY W. CROOKES, F.C.S.

NOT only figuratively, but in actual reality, can the life of man be compared to a fire, or lighted candle. Respiration may be regarded as the same process as combustion, only performed in a slower manner. Fuel is placed in a furnace, and the combustion which we see take place with the evolution of heat and light is owing to the combination of the oxygen—that wonderful constituent of the atmosphere—with the carbon and hydrogen of the fuel. In a similar way we place food (which is fuel) in our bodies, and then by the act of respiration we draw into the lungs oxygen; and this, uniting with the carbon and hydrogen of the food, also produces a disengagement of heat.

Another point worthy of attention is, that the combustible matter of the food—the carbon and hydrogen—when burned in the body by means of air drawn in by the lungs, produces exactly the same amount of heat as it would have done had the same quantity been consumed in an ordinary furnace by means of the free atmospheric oxygen; the only difference being, that in the latter case the combustion takes place rapidly, evolving an intense heat for a short time, whilst in our bodies the fuel is burned more slowly, thus evolving less heat for a longer time, the total amount of heat liberated by the combustion of a given weight of carbon, whether it be burned in the form of coal or beef, being always the same.

This, therefore, is the cause of the high temperature of the human body. We each carry about within us a portable furnace of the most perfect construction. Fuel is thrown on at intervals during the day, the need of a fresh supply being made known by the feeling of hunger (as it is in some steam-engines by the ringing of a bell); whilst a draught of air is drawn in at each inspiration, by which means the process of combustion proceeds uninterruptedly.

The analogy is strictly correct, even if pursued further. In a furnace we can augment the energy of combustion by increasing the draught of air; and so in our bodies, if we increase the normal number of respirations per minute, a considerable rise of temperature is the result, the excess of heat being radiated into the surrounding atmosphere, and carried off

in the form of perspiration. This explains why persons in Arctic regions consume such enormous quantities of food in comparison with those in more temperate latitudes. In order to keep up the natural heat of the body (which is invariably the same—99° 5′ Fahr.) in the midst of the intense cold of the surrounding media, it is necessary for considerable quantities of fuel to be rapidly burned in the body, so as to restore the amount of heat lost by radiation; and not only is the total weight of food which is required in the Arctic regions vastly greater than that consumed in warm climates, but the former contains a greater percentage of combustible matter; the fruits which constitute so large a proportion of the food of the inhabitant of the South containing not more than about twelve per cent. of carbon, whilst the blubber or fat which forms the staple diet of the Esquimaux or Lap, contains nearly eighty per cent. of that combustible. Plenty of food, therefore, takes the place of clothing, in the same manner as warm raiment is a partial substitute for food. The warmer we are clad the less fuel it is necessary to burn in order to keep up the supply of animal heat lost by radiation; whereas, if we were to walk about naked or were exposed to an Arctic temperature, we should be enabled to consume twenty or thirty pounds of whale's fat together with several quarts of train oil and brandy without difficulty, finishing off with a few tallow candles, by way of dessert, the combustible matters here indicated being not more than sufficient to supply the enormous radiation of heat consequent upon a difference of perhaps 120 degrees between the temperature of the body and that of the external air.

The analogy between the life of man and the flame of a candle or stove, is thus seen to be something more than a mere fanciful theory. Warmth and vitality are produced equally in each case by the combination of combustible matter with the oxygen present in the atmosphere; and in either case, if the supply of air be insufficient or vitiated, a similar result will follow; for the pale, sickly, flickering flame of a candle burning in an atmosphere deficient in the necessary supporter of combustion, or containing noxious gases, is strictly parallel to the delicate, sickly, etiolated appearance caused in human beings by an impure atmosphere, whilst the ultimate result is the same in both cases, namely, the extinction of vitality, or death.

An attentive examination into the phenomena of combustion, as exemplified in the burning of a candle, shows us, therefore, that not only is it necessary to take account of the food which we eat, that is to say, of the fuel with the combustion of which we keep up the requisite temperature; but that a careful attention to the quality of the air we breathe is no less important to our health and comfort. A candle burning in a close room not only consumes

a certain quantity of the vivifying principle of the atmosphere, diminishing the amount of oxygen present and available for other purposes, but it likewise communicates to the air an equal volume of another gas—carbonic acid,—a substance possessing the most deadly properties—the pure gas suffocating animals placed in it as if they had been plunged into so much water. Even when it is present in the air in only small quantities, it produces very deleterious effects, 4 per cent. acting like a narcotic poison in the atmosphere, and even a less proportion producing depressing effects of a most injurious description. If, then, a candle which consumes so small a quantity of oxygen causes such a change in the atmosphere, how much more will the respiration of human beings tend to vitiate it. It has been calculated that a man every twenty-four hours consumes nearly 400 cubic feet of air, with evolution of the deleterious carbonic acid gas; and that were he to be enclosed for twenty-four hours in a room eight feet square by nine feet high, he would be moribund at the end of the time. And these are not merely fanciful or supposititious cases. The action of contaminated confined air upon the health of the inhaler is one of the most potent and insidious causes of disease. Any addition to the natural atmosphere that we breathe must be a deterioration, and absolutely noxious in a greater or less degree. Our health, says Thackrah, would immediately suffer did not some vital conservative principle accommodate our functions to circumstance and situation. But this seems to get weaker from exertion. The more we draw on it, the less balance it leaves in our favour. The *vis vitæ*, which, in a more natural state, would carry the body to seventy or eighty years, is prematurely exhausted, and, like the gnomon shadow, whose motion no eye can perceive, but whose arrival at a certain point at a definite time is inevitable, the latent malaria, which, year after year, seems to inflict no perceptible injury, is yet hurrying the bulk of mankind with undeviating, silent, accelerating rapidity to a premature grave. Pure air is the food designed by nature for the constitution. Man subsists upon it more than upon his meat and drink; and there are numberless instances of persons living for months and years on a very scanty supply of aliment; but no one can subsist even for a few minutes without a copious supply of the aërial element.

Deaths from the respiration of many persons in a confined space are, unhappily, not rare; and without going back to the shocking instance of the Black Hole at Calcutta, we may refer to an equally lamentable occurrence which happened a few years ago in an emigrant ship, in which, during a storm off the English coast, the emigrants were confined below. In less than six hours more than sixty persons perished!

The paramount necessity which exists, according to these instances, for fresh air, equally holds good in less extreme cases. Just as surely as a total deprivation of oxygen, or the presence with it of any excess of deleterious gases, produces death; so the breathing of a partially-inhaled atmosphere is equally certain to occasion sickness and disease, if its inhalation be persisted in. The evils of exhausted air are also more to be guarded against, because persons can live in it without being aware of its danger, as far as their sensations are concerned. When we enter a crowded assembly on a cold day, the air is always at first repulsive and oppressive; but these sensations gradually disappear, and we then breathe freely and are unconscious of the quality of the atmosphere. Science, however, reveals the fact, that the system sinks in action to meet the conditions of the impure air; but it does so at the expense of a gradual depression of the vital functions; and when this is continued, disease follows. *No disease can be thoroughly cured when there is a want of ventilation.* It is related, that illness continued in a family until a pane of glass was accidentally broken, and then it ceased: the window not being repaired, a plentiful supply of fresh air was admitted. Nearly all the churches in the empire require some artificial means of ventilation to render them physically fit receptacles for the body during a prolonged service. The Sunday-schools also, as a general rule, are *very ill ventilated;* and lessons in the second hour are far worse rendered than in the first, solely arising from a semi-lethargic coma that comes over the pupils breathing a carbonic air, which has already done duty and been inhaled by others several times. However much to be regretted, it is still true that people will sometimes sleep during the sermon. Now, the minister must not be twitted with this; for with the oratory of a Jeremy Taylor, or of a Tillotson, people could not be kept awake in an atmosphere charged with carbonic acid, the emanations of a thousand listeners.*

Instances innumerable might be pointed out in connection with our trades and professions, showing that no one can break with impunity the law of nature, which demands that the food destined to nourish and warm the body should be converted into heat, and vitalized by a constant supply of fresh and pure air. The importance of this subject becomes more evident if we turn to a few statistics. In a life of fifty years a man makes upwards of 500 millions of respirations, drawing through his lungs nearly 170 tons weight of air, and discharging nearly 20 tons weight of the poisonous carbonic acid. It has been also calculated that, to ventilate a room effectually, every person

* Piesse.

requires ten cubic feet of fresh air per minute;* a church, therefore, 80 feet long, 50 feet wide, and 40 feet high, and containing 1,000 persons, would require the whole atmospheric contents of the building to be renewed every sixteen minutes. A room containing a million cubic feet of air, in which were assembled 10,000 persons, would likewise require a total change every ten minutes; and an apartment twelve feet each way, with ten persons in it, would require an entire change of air every seventeen minutes.

This quantity of ten cubic feet of air per minute for each individual, is what is required to supply him with the amount of oxygen necessary for the performance of the functions of respiration; whilst the constant change of the atmosphere is imperatively necessary to get rid of the products of respiration, viz., the carbonic acid and aqueous vapour, as well as the effluvia from the body; for, disagreeable as it may be to refer to such a subject, this is the most noxious cause of contamination with which we are in the habit of coming in contact. "We instinctively," says Bernan, "shun approach to the dirty, the squalid, and the diseased, nor use a garment that may have been worn by another; we open sewers for matters that offend the sight and smell, and contaminate the air; we carefully remove impurities from what we eat and drink, filter morbid water, and fastidiously avoid drinking from a cup that may have been pressed to the lips of a friend. On the other hand, we resort to places of assembly, and draw into our mouths air loaded with effluvia from the lungs and skin and clothing of every individual in the promiscuous crowd: exhalations, offensive to a certain extent from the most healthy individuals, but which, rising from a living mass of skin and lung in all stages of evaporation, disease, and putridity, and prevented by the walls and ceiling from escaping, are, when thus concentrated, in the highest degree deleterious and loathsome."

The evils produced by allowing the carbonic acid from the breath to accumulate in the air, have been already mentioned; those engendered by inhaled animal effluvia are still more fatal in their results; for, according to competent authorities, it seems to be an invariable result that the accumulation and stagnation of the breath and perspiration of human beings crowded for a period in confined air, and neglecting personal cleanliness, produce plague or fever that may be communicated to healthy persons by contact or respiration. The most memorable

* This is the minimum which should be allowed. In the House of Commons, which is, perhaps, the most perfectly, as it is certainly the most scientifically, ventilated building in the world, Dr. Reid never allows less than thirty cubic feet of air per minute for each member, when the room is crowded, and on many occasions sixty cubic feet have been allowed.

example of this is the Great Plague of London, which was caused by the total absence of proper ventilation in the filthy and overcrowded hovels in which the greater part of the poorer population of London lived, together with the filth and putrefying abominations which habitually filled not only the streets but even the houses of the lower classes. According to Bernan, the gaol fever was another disease which, arising from a neglect of the vital necessity for fresh air, was, a few centuries ago, an object of dread to society. The unfortunate and the criminal alike are immured in damp, cold, ill-aired dungeons, and kept in a state of inactivity. They inhaled the pent-up noxious effluvia emitted from their own bodies; and, from the want of means for personal purification, their clothes and bedding during their incarceration became saturated with the fatal exhalations. In this condition the miserable prisoners engendered, and became victims to, a disease of deadly malignity. They sickened, and with little apparent illness they died. The prison-house was thus the focus of a contagion that spread far and wide beyond its walls, and spared few who were so unhappy as to come within its influence. It was remarked, that although a prisoner happened to escape the infection, his clothes, nevertheless, emitted a pestilence that scattered death around him wherever he went. The assizes held at Oxford in 1577 were long remembered, and were called the *Black Assizes*, from the horrible catastrophe produced on that occasion by the gaol fever. Baker, in his Chronicle, tells us, that *all* who were present in court died in forty-eight hours—the judge, the sheriff, and 300 other persons!—so terrible was the retribution suffered by the community for its hardness of heart in denying to criminals even those personal requirements necessary for avoiding disease and preserving life.

Another similar catastrophe is recorded by Blaine as having occurred in 1750. During the sessions a sickening, nauseous smell was experienced by the persons in court, and within a week afterwards many who had been present were seized with a malignant fever. Among those who died were the Lord Mayor, the two judges, an alderman, a barrister, several of the jury, and forty other persons. It was remarkable that the prisoners who communicated the infection were not themselves ill of fever; and it was still more remarkable that none of those who were ill of it (to the greater number of whom it proved mortal) communicated it to their families or attendants; which showed that persons who were treated in clean and airy apartments, as those were who fell victims to it, do not communicate the disease to those in the constant habit of attending upon them.

Historians relate with just indignation that nearly three hun-

dred martyrs died at the stake in the reign of the bigot Mary. But how insignificant appear the number and sufferings of these victims of regal fanaticism when compared with the tortures of suffocation and death from stench, that were endured by thousands of persons in this and succeeding reigns, when every prison was a legal sepulchre!

Equally striking are the *good* results which have followed a judicious application of ventilation where it was formerly absent. It is scarcely possible to conceive a more repulsive and abominable state than that in which our ships of war were during the latter part of the last century, owing to the disregard, or rather the studied opposition, with which those then in authority treated all proposals to improve their ventilation. We regard other nations with whom we happen to be at war as our enemies, but a few figures, eloquent in their simplicity, will convince any one that incapacity, narrow-mindedness, or obstinacy in high places, are vastly more fatal in their results to our gallant sailors than the most formidable enemy they ever faced. In the year 1779 there were 70,000 seamen and marines voted by Parliament; of these 28,592 were sent sick to the hospitals, or 1 in 2·4. In 1784, of 85,000 men afloat, 21,371 were sent ashore sick within the year, or 1 in 4. But in 1804, when ventilation was partially, if not thoroughly, carried out in every ship, of the 100,000 men of which the navy that year consisted, 11,978 passed through the hospital, or only 1 in 8·3.

The evils of inefficient ventilation have been strikingly shown in the case of the Custom House, where the difficulty of ventilating a large public room has been very manifest. There the atmosphere in some of the apartments was so defective, as to produce general symptoms of ill-health among the officers whose official seats were placed in it. The functionaries were described to have had "a sense of tension or fulness of the head, with occasional flushings of the countenance, throbbings of the temples and vertigo, followed not unfrequently by confusion of ideas," that must be very disagreeable to persons occupied with important and sometimes intricate calculations. A few were affected with unpleasant perspiration at their sides. The whole of them complained of a remarkable coldness and languor at their extremities, more especially the legs and feet, which became habitual. The pulse in many cases was more feeble, frequent and sharp, and irritable, than it ought to have been. The sensations in the head occasionally rose to such a height, notwithstanding the most temperate regimen of life, as to render cupping requisite, and at other times depletory remedies; and costiveness, though not a uniform, was yet a prevailing symptom.

The identity between the combustion of a candle and that living kind of combustion which is ever going on within us has

thus been clearly exhibited. Like the candle, man depends for his life and vigour upon the chemical action exerted between the atmosphere and combustible matter; the combustion of the latter giving rise in each case to heat and vitality. Like the flame of a candle, too, man's health and strength languish and faint unless properly and uninterruptedly supplied with that mysterious breath of life—oxygen; whilst the feeble hold which the flame, even under the most favourable circumstances, has upon the wick, and the ease and totality of its extinction by the most trivial circumstance,—not only by a deprivation of air, but even by a puff of wind too much,—should teach us, even in our pride of health and strength, that our spark of life may be extinguished by the same causes, and our bodies may be left lifeless as a snuffed-out candle; the food—the combustible matter—may be there all the same; the oxygen may be in waiting, ready to combine with it; but the spark of fire, that spirit of life which man receives direct from his Creator, is absent, and without this all else is as nothing.

One more lesson from our candle, and we have done. What becomes of the human soul when it has left the body? What becomes of the flame when the candle is extinguished? Must our philosophy halt here? or will it turn round upon us and attempt to prove, in scientific jargon, that there is no such thing as a future? We think not. We believe, that as the relationship between the candle and man bears strict analogy from the first kindling of the mysterious vitalizing principle, through the varied phenomena of life, in sickness and in health, and even in the more mysterious phenomena of extinction,—so can the analogy be carried further into the dim shadowy realms beyond.

If there is one question more than another which has occupied the attention of modern philosophers, it is that relating to the *conservation of force*, or, as it sometimes is called, *of energy*. It has long been admitted that matter can neither be created nor destroyed, and the whole tendency of modern discovery is now directed to show that *energy* is equally incapable of extinction. So long as it is exerting its action in a definite way, shining and glowing as a candle flame, evolving the *forces* of heat and light, we take note of it by means of our outward senses; but when the flame goes out, are these forces annihilated? Assuredly not. The energy which hitherto was occupied in the production of heat and light has only changed its immaterial form; it still exists in undiminished quantity, though it is now incapable of appreciation by our material senses. For just as the forces evolved by burning fuel are transformed into mechanical motion in the steam-engine; and just as mechanical motion is equally capable of being retransformed into heat,

light, electricity, or chemical action,—just as every word we utter acting on the material atmosphere around us resolves itself into aërial waves of sound, which for ever afterwards vibrate with diminishing intensity, but expanding area, from one extremity of the atmosphere to the other, retaining always the same amount of energy as it did when the mechanical motion of the breath and lips first gave it birth,—so do the forces once born to activity when the candle is lighted live to the end of time undiminished in intensity, although changed in character. When the flame is naturally extinguished these living forces do not die, but become absorbed into that vast reservoir of energy which is the source of all life and light upon this globe.

And shall we then suppose that the soul of man is of less account than the flame of a candle? If philosophy can thus prove that the latter never dies, shall not faith accept the same proof that our own spiritual life is continued after the vital spark is extinguished?

THE WEST COAST OF EQUATORIAL AFRICA.

BY THE EDITOR.

THE exciting stories of the gorilla-hunt, the description of "Fan" cannibals, naked, yet armed to the teeth, for we are told that they file their teeth to points to inspire terror in their enemies (and, we presume, the more readily to *masticate* them afterwards!), and the record of showers of ebony wives poured in upon the adventurous and favoured white traveller,* have but ill prepared the public mind for the reception of a sober working-day account of the western shores of Equatorial Africa.

Nevertheless, there are, doubtless, many whose curiosity has been awakened by these wonderful narratives, and who, desirous of becoming better acquainted with this portion of the world, will receive as welcome information a few leading facts on the subject, gathered from authentic sources, and published without embellishment. These it is our intention in the present brief essay to contribute.†

If the reader will refer to the annexed map, and will place his finger a little to the west of the Greenwich meridian, and about 5° north of the equator, he will find that it covers the British colony of Cape-Coast Castle, where civilization has already made sufficiently rapid strides to admit of the establishment of a newspaper,—the *West African Herald*, which disseminates valuable information concerning the condition of the western coast.

Moving eastward, he will have to cross the river Volta, which divides the two famous monarchies of Ashantee and Dahomey, the seats of a thriving trade in human flesh, and the dominions of potentates who do honour to their predecessors on the throne by digging pits "to contain human blood enough to float a canoe," and by filling them with the life-blood of thousands of their unoffending neighbours, whom they attack, capture, and slaughter for the "grand custom."

With these august potentates, her Majesty's government is vainly endeavouring to negotiate treaties for the discontinuance

* "Explorations and Adventures in Equatorial Africa." P. B. Du Chaillu. Murray. 1861.

† We are indebted for much of the information contained in this paper to J. A. Tobin, Esq., of Liverpool, who unreservedly, and with great kindness, placed at our disposal the whole of the correspondance of his firm with their agents on the West Coast of Africa. We have also received many valuable data from Alfred M. Power, Esq., of Liverpool, who resided many years in this part of Africa, and from other gentlemen engaged in the African trade.

of the odious traffic in slaves. His late majesty of Ashantee, although he said that he "loved and respected the English character, and nothing afforded him such high satisfaction as to see an Englishman in his country and do him honour," could not consent to give up the slave-trade, "as it afforded him his chief means of revenue, and he held his power by the observance of the *time-honoured customs* of his forefathers."

The present ruler and his neighbour of Dahomey, both continue to carry on an active trade in human beings, despite the remonstrances of all civilized nations; and here it is that cannibalism, fetish-worship, witchcraft, and all the horrors of barbarism still reign uncontrolled, notwithstanding the efforts of missionaries, traders, and progressive civilization.

Leaving this land of promise, we shall request the reader to travel rapidly along the coast, which takes a bend southwards, and in so doing he will pass through Benin, and will cross what are commonly called "the Rivers;" namely, the mouths of the Niger, the Brass, Bonny, and Calabar rivers, and the river Cameroons. Here he may breathe with greater freedom under the assurance that the terrible slave-trade is giving place to a legitimate traffic with Europeans, chiefly in palm oil, but also in ivory, gold, ebony, &c., and (from Benin) in palm nuts, which yield a fine description of palm oil. Passing on, we leave to the westward the island of Fernando Po, a Spanish settlement; and travelling along the Bight of Biafra, the district concerning which Consul T. J. Hutchinson has recently published such valuable information,* we soon arrive at the Gaboon river, where it will be necessary to pause for an instant.

The banks of this river, and indeed the whole coast over which we have just travelled, are in the possession of native chiefs; but on the north bank is a French colony, and on this river a considerable trade is carried on between the natives and various European nations, in ivory, red and white barwood, ebony, india-rubber, beeswax, gum-copal, &c. &c. To the north and south of the Gaboon are the rivers Muni, and the Fernand Vaz and Nazareth, forming, according to Du Chaillu, the mouths of the Ogobai. To the eastward, from 100 to 200 miles inland, there run from north-west to south-east one or more ranges of high mountains, which extend with more or less regularity along the whole coast under consideration, and are called here the Sierra del Crystal. This is the region rendered famous by Du Chaillu, whose adventures have of late excited so much controversy; and here it is that the fierce gorilla, a gigantic anthropoid (or man-like) ape is said to roam,

* "Ten Years' Wanderings among the Ethiopians." T. J. Hutchinson, F.R.G.S. Hurst & Blackett. 1861.

the undisputed monarch of the wilds. To the west of the Gaboon river, in Corisco Bay, is the island of that name, where, as also on the mainland, the Americans have planted missionary stations, schools, &c.; and this is perhaps one of the most promising districts on the whole western coast.

Here the so-called "south coast" commences, and continuing southward we enter Loango, a country ruled by a negro king, where the odious slave-trade is carried on with all its concomitant horrors. Hurrying through this dark region, we reach the river and the territory of Congo, ruled by a number of petty kings, all owning allegiance to one great king, who resides at St. Salvador in the agreeable proximity of the Portuguese, who have recently pushed their forces into the heart of his dominions, and erected a fortress in his very capital—St. Salvador.

Although the Portuguese have thus extended their colonies *inland*, the English government denies their right to occupy the coast, where they have attempted to levy duties upon our merchants, forcing them in some instances to shift their stores; and it is not until we arrive at the river Loze, or Ambriz, that we find them in undisputed possession of the soil.

From this point southward to about Mossamedes, the Portuguese colonies extend, and at the capital of *Angola*, St. Paul de Loanda, they have regular military and customs establishments. An excellent account of this place will be found in Dr. Livingstone's Travels, for it was here that he terminated, in the summer of 1855, his arduous journey across the African continent; and from hence he took his departure on his return to the opposite coast.

From St. Paul de Loanda and the neighbourhood, the chief produce exported consists of copper ore (malachite), palm oil, ground nut oil, orchella-weed, pepper, camwood, barwood, ivory, coffee, and hides; and were it not for the difficulty in conveying merchandise to and from the interior, of which we shall speak hereafter, a very excellent trade would be carried on between this port and Europe.

Our journey is now at an end. From this point we might travel southward as far as Little Fish Bay, or Massamedes, and still remain on the Portuguese territory; but having briefly noticed the various countries that constitute the coast of Western Equatorial Africa, we shall now direct our attention to those features of general interest by which it is characterized.

As a rule, the coast is flat, and in many places swampy; on proceeding inland, however, the land is found to rise, and at distances varying from fifty to two hundred miles, it becomes high and mountainous. From the Bight of Biafra almost to the Gaboon the shore is swampy and unhealthy (except in the proximity of the majestic mountain of Cameroons, which rises

above fourteen thousand feet over the level of the sea); but further south it is in many places skirted with cliffs.

The seasons on the coast* are threefold, and may be described in general terms as follows:—The three seasons are called *rainy*, *dry*, and *smoky*. It is difficult to state with exactitude when these seasons begin and when they terminate, for our authorities (some of whom have resided many years on the coast) do not all agree on the subject; but approximately the heavy rains, which are ushered in by tornadoes, last from about February to May or June; then cold, hazy weather sets in, and small drizzling rains prevail. This is the smoky season, which lasts until about September; and from that time until the rains recommence early in the year, it is hot and dry, the thermometer averaging 83° in the shade. Strangely enough, however, the hot season is the most healthy; for it is during the smoky and rainy seasons that the fevers are most virulent.

The diseases to which Europeans (and, in a less degree, the natives) are subject, are, on their arrival, bilious and gastric fevers; then dysentery, agues, and yellow fever. The universal antidotes in cases of fever are large doses of quinine and emetics. Often, unfortunately, the patient has recourse to spirituous liquors, and it is hardly necessary to say that their deadly effects are sooner felt in this unhealthy region than in our own temperate climate.

If a casual reader tried to gather from the published works of travellers, or even from the conversation of friends who have resided on the coast, what is the general nature of the climate, he would find it very difficult to arrive at a satisfactory conclusion, for every one speaks "as he found it;" some describing it under the influence of sickness, after a weary journey, others having never left some one healthy spot on the coast; so that it is quite impossible to reconcile their ideas on the subject.

Both on the coast and in the interior, it is, as a rule, decidedly unhealthy and trying to Europeans, and will remain so *until the land is cultivated and reclaimed*. Nor is it to be wondered at, so long as bogs and mangrove swamps exist, that the miasma arising therefrom should breed fevers and agues. It must also be mentioned that, although there is generally a change of seasons, yet it not unfrequently happens that during eighteen months there is not a single downfall of rain.† Under such circumstances, the streams dry up, vegetation decays, and, to use the expression of a resident, "the natives die like rats."

* This refers to the coast south of Cape Lopez. In the bights of Biafra and Benin the rains last from October to January, and the remainder of the year is hot and dry.

† From Cape Lopez southward there is sometimes not a single downfall of rain for twenty-four to twenty-six months !

The interior is not, however, so unhealthy as the coast, and not only is the air more salubrious, but here and there is to be found scenery of surpassing loveliness. Dr. Livingstone, and other travellers, have described many picturesque spots; and it may lend a little interest to our matter-of-fact inquiries, if we here introduce an extract from the letter of a gentleman formerly resident at Ambriz, descriptive of an interesting locality in the neighbourhood of that settlement. He had set out with a companion, on a visit to the "king" of Ambriz, and on their arrival at the village in which he resided, their attention was attracted by a high mountain near at hand. During their audience, they expressed a wish to mount the hill; but the king endeavoured to dissuade them from so doing, by relating horrible stories of the dangers they would encounter.* This, however, only sharpened their curiosity, and they determined to make the ascent.

"We had no sooner declared our determination, than plenty of volunteers were ready to accompany us, and we soon found that there was no cause for fear. A tolerable footpath led right up to the top, and half an hour's climbing presented us with the noblest scene I think I ever beheld! Far down below our feet, almost immediately under us, was the river (Ambriz), which we now saw, for the first time, winding along, its banks verdant with corn and every production of a tropic clime; oranges and limes, cotton and sugarcane, all grew wild in great luxuriance. We could trace the river far inland, now hidden by trees, then again shining forth bright as a sheet of silver! It seemed not a continued stream, but a succession of small lakes, each one more beautiful than the other. Sometimes it was lost for a long distance amongst wooded hills, and then again we caught a glimpse of it afar off, till at length it was lost beyond a range of lofty mountains."

This description of the river Ambriz or Loze, would almost carry one in imagination to the banks of the Rhine, or to some gentle slope in the English Lake district. We must now, however, pass from an attractive and pleasing topic, to a repulsive, but still interesting one; namely, from the smiling landscape to its degraded and unfortunate inhabitants.

We have no space to impart to this practical review even a shadow of romance, nor in any way to soften down the dark features that present themselves to our notice; and if the wonder-loving reader desires to hear negresses spoken of as "belles," or to see their picturesque head-dresses (formed of their own *wool*, intermixed with the *hair*, tail, and pieces of skin of the buffalo, and plastered with a cosmetic composed of palm oil and white clay, scented with a sweet-smelling rosewood!) we must refer him to the published works of Dr. Livingstone, and other adventurous travellers. But we have here to deal with the natives, as a trader or colonist finds them. On all

* A friend (formerly resident there) expresses the opinion that the "horrors" consisted of a slave barracoon.

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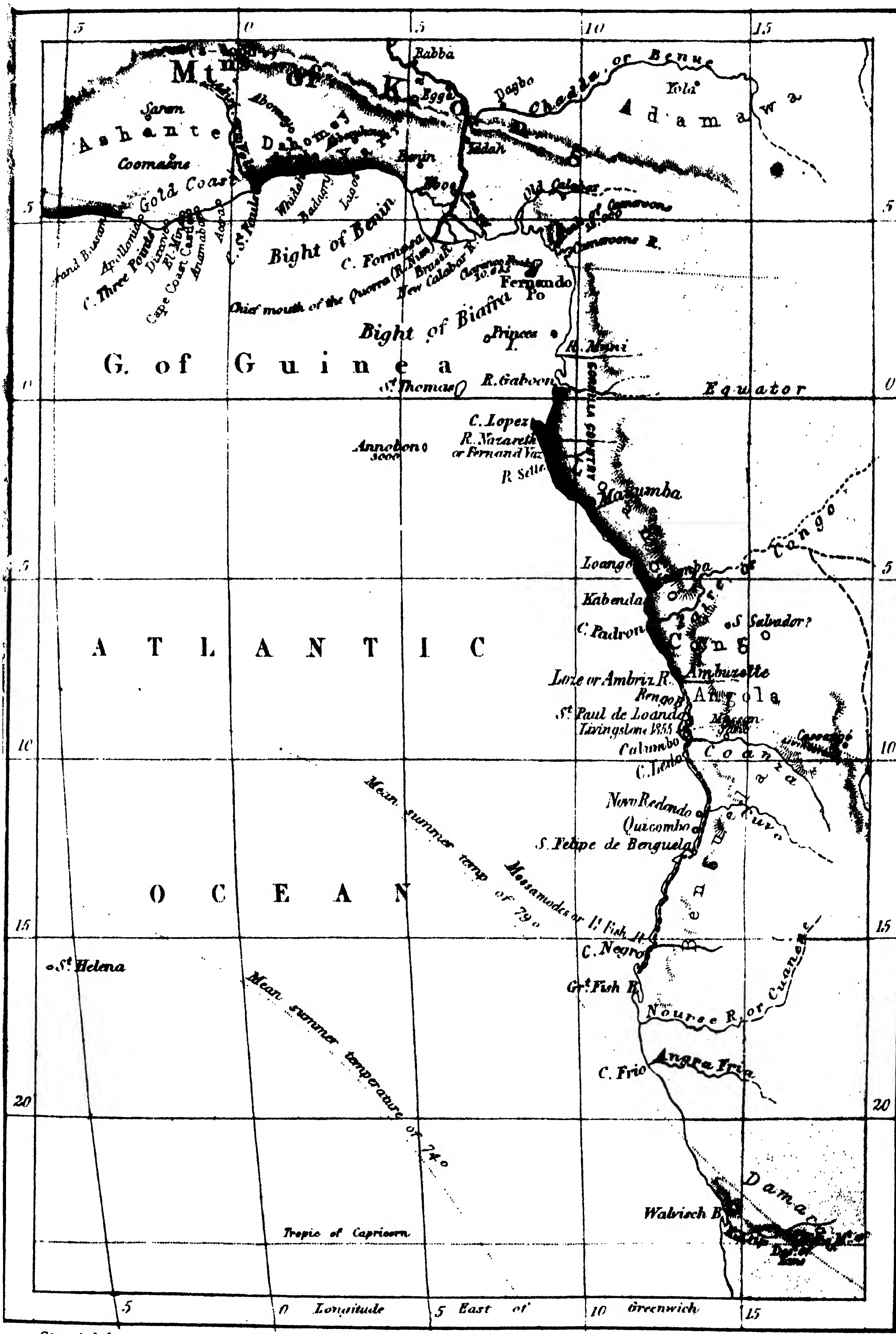
OUTLINE OF THE WESTERN COAST OF EQUATORIAL AFRICA.



Portuguese........Orange.
British ....Crimson.
Native................Green.
Seat of Slave Trade, Black.
Doubtful ▬ ▬ ▬ ▬ ▬

sides, from Englishmen, foreigners, and free men of colour, we hear but one opinion, modified indeed in its expression, but invariably the same in substance. "The negroes are an indolent, bad race," they don't and won't work; the women do all the field labour, planting mandioca (*Anglicè*, manioc, of which more hereafter), carrying heavy burdens, nursing, cooking,—in fact, doing everything but "drinking" (and in many cases that also). The men eat, drink, fight, "palaver" (quarrel), and sleep. Of their horrible "fetish-worship," superstition, human sacrifices, and cannibalism, practised especially in Ashantee, Dahomey, Loango,* and other parts where the civilizing guns of the Europeans have not yet resounded, we have no room to speak; besides, enough has been *said*, and too little *done* to suppress these barbarities; but even where the temptations of gain have to some extent brought them within the pale of civilization, the African negroes are as bad as the worst of our European dealers, being the most unscrupulous traders to be met with on the face of the earth.

Although our information fully justifies us in making this sweeping assertion as regards the coloured men inhabiting this part of the world, we do not mean thereby to impugn the character of the whole race. Even in this region many honourable exceptions are to be found; and without at all referring to those who are in a state of servitude in America, or who have, through their education, been placed on a perfect equality with the white man, we shall, when we come to speak of the trade of the coast, be enabled to show that the honesty of the blacks might *in some instances* serve as an example to the more highly endowed European.

Before passing away from this part of the subject, we must say a few words concerning the means that have been employed to reclaim this unfortunate branch of the human family. Of their wholesale deportation, by fraud and violence, to the plantations of Cuba, or wherever they may be consigned to servitude, little need be said; for the voice of civilized nations has declared this to be an unlawful act, and it is only a matter of surprise that it is not reckoned amongst the gravest of human crimes. Although the worldly condition of the negroes (at least, of such as reach their destination) may be somewhat ameliorated by the transference, yet the process is instigated by the most sordid motives, conducted without the smallest regard to humanity, and often accompanied throughout by horrors as indescribable as those enacted in the home of the negro.

* *Cannibalism* is not practised at Loango, but at Goanzo, up the Congo, and in the district of Cape St. Braz, a little south of Loando, Fetish-worship is prevalent along the whole coast.

Again, if we are to believe the testimony of truthful and disinterested informants who have resided years on the coast, the missionaries have, so far, produced little or no impression on the savage nature of the inhabitants. This arises chiefly from the degraded state of the natives, but also to some extent from the want of unanimity and the sectarian spirit prevalent amongst the missionaries themselves; each denomination representing its own as the only true Christianity. What may be the result of schools and missionary labours hereafter, it is impossible to say; and perhaps when their teachings are supported by something better than the trader's rum, and are no longer illustrated by a code of morals which can be studied to advantage on the quays of our large towns, their efforts may be more successful; but at present fetish-worship and human sacrifice are carried on as openly as the day when the missionary first landed.

From its human inhabitants we naturally descend (not a great way, however!) to the *fauna* of the coast and its vicinity. The description of these alone would fill volumes; but our space will only allow us to name a few of the leading types.

Amongst the *Quadrumana* we find several large fierce apes, at the head of which stands the gorilla, a creature with whose appearance the world has been familiarized through the account given of it by M. Du Chaillu. Very little is, however, known of the natural history and habits of any of these interesting animals.

Bats are present in great numbers; and amongst the *Rodentia* we have several species of squirrel.

The leopard is the chief of the *Carnivora*, filling the place held by the lion and tiger in other parts of the tropics. It is accompanied in this group by the hyena, fox, &c.

Of *Ruminants* there is a great variety, the most characteristic being the wild bull, antelope, and gazelle.

But the most interesting, and by far the most useful, animals in this region, are found amongst the *Pachyderms;* viz., the elephant, hippopotamus, and wild hog; the two former yielding ivory and flesh meat, and the latter affording a supply of food to the natives.

A word concerning the elephant. At present it is mercilessly slaughtered by the natives for the sake of its valuable ivory; but there is no doubt, that in so doing they are, to use a familiar expression, "killing the goose for the sake of the golden egg;" and if this animal should not have been exterminated before civilization has planted its foot firmly upon these barbarous shores, it will, doubtless, become as useful a beast of burden as it is in India, and will perform the labour at present imposed upon the women.

Turtles, *birds*, and *fish*, without number, frequent the coast, and no sportsman need here complain of a dearth of game.

The most useful, as well as the most graceful, of all the *Plants* of this region, is the palm-tree, which yields that great civilizing medium, palm oil; and hardly less important, as commercial productions, are the india-rubber vine, the barwood, ebony, and several gum-trees. The natives themselves, however, find less use in any of these than they do in the shrub variously designated the cassava, mandioca, and manioc (*Jatropha Manihot*), almost every part of which is a staple article of food. It, however, requires a considerable amount of preparation before it is fit for use, as the root contains a deleterious substance, which must be washed out before it can be dried, ground, and baked. Agriculture is quite unknown in most parts of this region, and the natives depend almost entirely upon the manioc for sustenance—this failing them, they die of starvation.

Added to the plants just mentioned, there are in Liberia and one or two other parts, small sugar-plantations, and, except in extremely dry seasons, the soil is capable of producing cotton,* coffee, cereals, and the fruits of temperate climates.

Of the *mineral* productions little is known. Copper, in the form of malachite, is received in considerable quantities from Loanda; † gold from various parts of the coast, but not to any extent. There is no doubt whatever that iron is plentiful. In the interior the natives employ it to fabricate spear-heads, knives, &c., and prefer these home-made productions to those they receive from European traders. Dr. Livingstone describes the ruins of an iron-foundry erected as far back as 1768, by a Portuguese nobleman, on the river Coanza, and states that a party of native smiths and miners still work the rich black magnetic ore for the Portuguese government. The quantity of iron they produce is, however, inconsiderable.

Although there has never been any certain evidence of the existence of coal, there is little doubt that it will be found in considerable quantities, and in the neighbourhood of Ambrizette petroleum (mineral or rock oil) is very abundant.

It would be difficult to find anywhere a country better adapted for *trade* than this portion of Africa. Its rich tropical productions would furnish the materials for an enormous export traffic; its naked, unhoused, half-starved inhabitants would, if usefully employed, open a market for our home manufactures; whilst its numerous bays, creeks, and rivers, would afford the accommodation so necessary for a successful interchange of commodities.

* Dr. Livingstone found cotton further inland, and states that he purchased it at a penny per pound.

† The malachite is found at Ambrizette; but since the annexation of that place by the Portuguese, it has been conveyed to Loanda for shipment.

At Corisco, the Gaboon, Mayumba, Loango, Congo, Cabenda, Ambrizette, Loanda, Novo Redondo, Quicombo, Benguelo, Mossamedes, and many other places up and down the coast, vessels may ride at anchor in perfect safety, and some of the rivers are navigable for six hundred miles or more from sea.

At present the trade is conducted in a very primitive manner, either on the deck of the vessel that conveys the home manufactures from Europe and returns with the raw produce of Africa, or in "stores" on land, superintended by resident agents of the European houses.

In some cases the traffic is carried on by direct barter, the natives bringing their produce to the store or trading vessel, and receiving in return a quantity of European materials; at other times, the captains, supercargoes, or agents, trust the more honest native chiefs and their subjects with various commodities, for which they are expected to supply within a given time a certain quantity of palm oil, ivory, &c.

A cursory examination of the articles employed in this trade will give us a better insight into the character of the natives that all the opinions that have been expressed concerning them. We find, for example, that spirits, tobacco, gunpowder, salt, silks, cloths,* beads, guns, &c., are *always* in demand; whilst knives, buttons, rods of brass and copper, caps, shirts, paint, oil, lamps, and *soap*, are usually more or less at a discount.

Never do we find rum to be a drug; never is there a glut of gunpowder! nor are paint and soap ever "in demand."

Then as to the native chiefs, many of them are grand seigneurs in their own way. From one of them (King Peppel), we find the following order to a Liverpool firm:—"Four dozen sherry, four dozen porter, four dozen ale, one small cask white bread, one box wax candles!" and we are informed that on some parts of the coast, champagne, liqueurs, &c., are in great request amongst the chiefs.

The same articles which were in demand twenty or thirty years since are still in request; so that, excepting in some of the Portuguese and British settlements, the natives appear not to have made the slightest advance in civilization, save only as regards its vices and indulgences.

The evils of the "trust" system have, we believe, been very much overrated by travellers and others unacquainted with trade; for many of the largest houses declare that during the whole of their intercourse with the natives they have not lost ten casks of oil by this mode of conducting their business.†

* Used as a vestment round the middle; the only clothing that is worn.

† It is right to state that, in a report presented to the Board of Trade, Consul Hutchinson declares the trust system to be a vicious one.

A few words concerning the future of this region, and we have done.

A thoughtful writer on the subject* expresses himself completely at a loss to devise "some sort of education to root out the fell spirit" of this people, and thinks that "ages must pass by before any system can produce impressions of amelioration on temperaments such as they possess."

The *formation* of these habits has been the work of ages, and it is therefore probable that ages *would* elapse before they could be eradicated by any ordinary educational process.

Long before this can take effect, however, we venture to say that the soil will be in possession of the white man.

Meanwhile all the resources of civilization, trade, science, secular education, and religion, well supported by European arms, will be needed to reclaim the country and its inhabitants. Commerce has been, and will continue to be, the chief instrument of regeneration. The legitimate trade in produce will materially aid, as it has done, in suppressing the slave-trade; but before the former can be satisfactorily conducted, improvements in inland conveyance, by means of railways or tramways, elephants, and flat-bottomed boats upon the rivers, will have to replace the carrying trade as now conducted on the backs of women.

The monopolies of the coast tribes will also have to be broken through; but, in consequence of the jealousy of these, little hope can be entertained of any material improvement until the whole of the country has been brought under the subjection of Europeans.

Many of our readers will no doubt be startled at this assertion, and some, pointing to Liberia as an example of native rule, may protest against the theory of conquest. Whether or not Liberia is a "success" (for there is a great diversity of opinions on the subject), we cannot here decide; but certain it is that the great wave of progress will never be arrested in order to give time for the experiments of philanthropists; it will continue, as it began, to roll onward, preceded by the sword; but no doubt its progress will be characterized by the operation of expanding humanity and the appliances of the age.

Amongst these may be mentioned, as one of the most important and efficacious, the influence of the newspaper press.

Books, however useful they may be, are often written with an object, or, as we have seen of late, their contents are open to considerable discussion. However such works may please for the hour, they lose all practical effect upon the public mind, and their garniture familiarizes us with savage life, without inspiring

* Consul Hutchinson's "Ten Years' Wanderings among the Ethiopians," p. 79.

us with a sense of horror, with which we should be impressed by their perusal.

With journals, however, it is different. The African steamer arrives in Liverpool at night; and the next morning every statesman, man of business, and philanthropist, is informed at his breakfast-table that "the American and Portuguese slave-dealers are instigating the turbulent portion of the natives to quarrel with the British government on the coast, of which they will no doubt take every possible advantage to push the slave traffic;" or that "the king of Dahomey was sending down large droves of slaves to Whydah, and that there was no doubt entertained but that they would all be got off safe."*

Whatever doubt may have been expressed concerning "tales of travellers," no one will call into question the matter-of-fact information disseminated by the Press; and we trust that this mighty engine will soon be in full operation wherever Englishmen, Portuguese, Spaniards, or Americans, have planted their feet on African soil, and that its influence, combined with those already named, will soon transform the region which we have brought in so imperfect a manner under the notice of our readers, from a land of barbarism, desolation, and misery, to one of peace, plenty, and happiness.

* *West African Herald*, 29th April, 1861.

THE GREAT COMET OF 1861.

BY JAMES BREEN.

ON the night of June 30th, astronomers and the public in general were astonished by the appearance of a large and bright comet in the northern heavens. Those who saw it on that and the following few days, and who remembered and compared it with the other great comets of the present century, confessed that they had never seen anything so brilliant. Sir John Herschel, the Nestor of modern astronomers, writes, that "it far exceeded in brightness any I have before observed, those of 1811 and the recent splendid one of 1858 not excepted. It preserved the same magnificent appearance up to the 5th of July; but after this date it diminished greatly in size and lustre, although still a conspicuous object in the heavens. Even as late as the 17th of August I was able to see it with the naked eye."

No sooner had a sufficiency of observations been taken of the stranger, than astronomers set to work to discuss whether it was the great expected comet of 1264 and 1556, of which we had been promised a view for some years past. These bodies, as every one is aware, are supposed to have been one and the same; and not only are they celebrated on this account, but likewise for the historical events connected with their appearance. If we are to believe the ancient chroniclers in respect to the comet of 1264, it would seem that Pope Urban fell sick the very day the comet was first noticed, and died exactly on the day it disappeared! One old chronicler, bearing the somewhat appropriate name of Funckins, indeed mentions a quantity of supplementary mischief which it did on this occasion, in the shape of wars, plagues, drying up of springs, &c.; but the death of the pontiff was considered as the principal purpose of its mission to the earth. In 1556 it is said to have caused the abdication of Charles V., who, on seeing it, repeated the well-known sentence, "*His indiciis me mea fata vocant,*" and retired to a monastery.

The new-comer turned out, however, to be quite a different object from the mysterious body which exerted such a baneful influence on crowned heads. The comets of 1264 and 1556 cut the ecliptic at 175° of longitude; whilst the longitude of their least distance from the sun was about 280°. The inclination of their orbit to the ecliptic was only 30°, their least

distance from the sun was 44 millions of miles, and their motion was direct. These quantities, which determine the path of the comet round the sun, are altogether discordant with those given by the wanderer of June, 1861. According to my calculations, which agree with those of others, the longitude of the ascending node of the latter was 278° 59′; that of perihelion, 249° 15′. The inclination of the orbit to the ecliptic was 85° 39′; whilst its least distance from the sun was 78 millions of miles. The motion was direct. It will be seen from this, that we must yet be on the look-out for the comet of 1556, in case it has not already passed away unnoticed, a supposition which is becoming more and more probable every day.

Although, however, we were not fortunate enough to witness the reappearance of those celebrated historical comets, yet there were other circumstances connected with the present object which were scarcely less marvellous. From the calculations of Professor Hind, it would seem possible that the earth passed through the tail of the comet on the afternoon of June 30th, and an unusual glare in the sky was noticed by himself and several others on that evening, which was attributed at the time to an auroral light. When it is remembered (according to the calculations of the astronomer Olbers) that the probability of the earth coming into collision with the atmosphere of a comet could only occur once in 8 or 9 millions of years (the probability of the earth coming into collision with the *nucleus* of a comet, he calculates could only occur once in 220 millions of years), we may conclude within fair limits, that nothing of this kind has occurred since the creation of man. Had such an event been prognosticated, the terror which would have ensued may be easily imagined; nor would it have been altogether dissipated even if we took the more favourable views of the astronomer Pape, who computes that the distance of the tail of the comet from the earth was at least 2⅓ millions of miles on this occasion. We once heard St. Marc Girardin repeat a *mot* of M. Babinet, who asserted that the shock which the earth would receive from collision with a comet would be no greater than that received by a locomotive in full speed meeting with a fly. But the fly in this instance might cause as much alarm as the spider in another, of which the poet says—

> "There may be in the cup
> A spider steeped, and one may drink; depart,
> And yet partake no venom; for his knowledge
> Is not infected; but if one present
> The abhorred ingredient to his eye"—

the case would be different, especially when the poisoned atmosphere of a comet might be expected to mingle with and

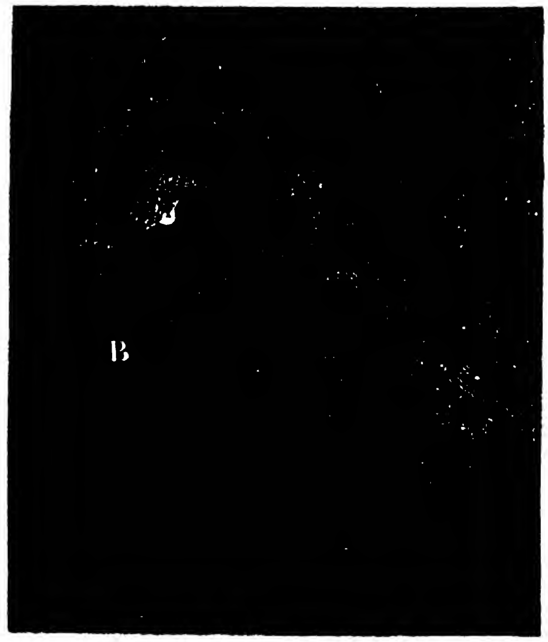
be diffused over the earth, according to the wild imaginations of Poe.

The telescopic appearances of the head and nucleus of the present object, although very remarkable, did not show the same extraordinary changes as were perceived in Donati's comet of 1858. We give a representation of the fan-like appendage proceeding from the nucleus, as taken by Mr. Wray on July 4, which, considering the excellent means at his command (a telescope of seven inches aperture), and the keenness of his vision, may be considered as the best view of the comet yet published. Mr. Wray states his surprise at the comparative constancy of the phenomena of the luminous sector over that of Donati's and other comets, it remaining nearly of the same size and brilliancy, and in the same direction, during the month of July. Sir J. Herschel states that on the night of June 30 the nucleus was very much condensed; and on the night of July 2 it was concentrated into a dense pellet of about 300 miles in diameter, but no unequivocal symptoms of a fan could be perceived. Although the luminous sector could not be perceived by the illustrious astronomer on the evening of the 3rd, yet on the early morning of the 4th it was certainly seen by several observers, and was very apparent in a telescope of five inches aperture belonging to J. Buckingham, Esq., C.E., with which I observed. On the evening of the 4th and 5th it was most beautifully visible; but instead of the appearance which it presented in Donati's comet, viz., that of looking through a partially transparent and hollow dome, the aspect was comparatively irregular, and the luminous jets and branches proceeding from the nucleus bore some resemblance to a pyrotechnic display. Those remarkable "hoods" of cometic matter which I saw in Donati's comet, in 1858, with the great Northumberland telescope at the Cambridge Observatory, and which were successively passing away from the nucleus, as beautifully described by D'Orsay in the Chancellor's Prize Poem of 1860, were wanting in the present instance:—

"Next rose to view a startling change of scene;
Round the bright nucleus waved a concave screen;
And radiant hoods, pure envelopes of light,
In slow succession gleamed upon our sight,
Volumes of lustre from the star disc came,—
Fold within fold, each marvellous coat of flame!
Watch the sharp throes of that tremendous birth,
As if the molten mass that fills our earth
Had burst its boundaries, fired and flung on high
The crust men call a continent; the sky
Blazing with light from each strange hemisphere,
Which sunward hurries in its swift career.
So in yon nucleus some explosive force
Launches each concave on its fiery course;

> Arch above arch, aurora-like, they rise,—
> Concentric canopies, cometic skies."

Mr. Wray noticed that the branches, or jets, proceeding from the nucleus alternated in brightness. The apparent left spur, marked A (as seen in an inverting telescope), which was very bright on July 4, afterwards became almost invisible, the others remaining nearly of the same lustre. On July 11, the head, which had hitherto been of a regular parabolic figure, became



narrower as it joined with the tail; the part B in the sketch (which was taken with my telescope of $3\frac{3}{4}$-inch aperture), was much brighter than the opposite side, and slightly convex.

The remarkable increase in the length of the tail between June 30 and July 4 may be considered as astounding, even in this marvellous class of objects. Sir J. Herschel considered the length of the tail on the former evening as 30°, which, at the then distance of the comet, would be about $6\frac{1}{2}$ millions of miles in length. On July 4 he considered it as 80° in length, or the actual length would be about 27 millions of miles! The phenomena which were going on within the canopy of flame termed the luminous sector, or fan, were, it is true, on a less gigantic scale; but what prodigies of creative force and energy were even there evoked!—the "pellet" of concentrated light (as it was designated on June 30), called the nucleus, a few days later throwing up mighty columns of nebulous matter towards the sun, forming a dome of inconceivable girth (some 35,000 miles from the spot it sprung from and enveloped), and then flowing silently backwards and adding millions of miles to the milky train following the meteor. We can only imagine some cloud-like formation of extreme tenuity to be capable of these sudden changes, and even then under the influence of some overpowering force.

It may be mentioned, in conclusion, that no signs of polarity could be perceived in the light of the comet, although experimented on with the most delicate instruments by Sir John Herschel. Neither could the slightest image be perceived on a highly-sensitized collodion plate, although M. De la Rue, who endeavoured to procure it, was able to obtain it in the case of Donati's comet of 1858.

The comet is still visible in the northern heavens, although, from its great distance from the earth, powerful instruments must be used in order to catch a glimpse of it. Its distance on Sept. 28 is 205 millions of miles, and it is situated at R. A. 16h. 9m., and 48° 14′ of north polar distance, according to the foregoing orbit which I have calculated.

REVIEWS

AND SHORT NOTICES OF BOOKS.

THE PAST AND PRESENT LIFE OF THE GLOBE.*

THE history of man's dwelling-place must always be to him a subject of deep interest, not only in so far as it concerns the beneficent designs and operations of the Creator in preparing it for his reception, but also as a guide in his speculations upon the probable future of his race.

Our readers are, doubtless, well aware that there are various theories with respect to the changes that took place in the earth's crust, and in the nature of the living forms upon its surface, before the advent of man,—theories that have been unwisely debated, with considerable acrimony, in consequence of their bearing upon matters connected with theological belief. Some of the students of the earth's history entertain the conviction that the strata which constitute its external crust were formed at distinct intervals, succeeding one another, and that between each such interval there was a violent "cataclysm" (literally a "washing down"—a deluge, in fact), which destroyed all living organisms, animal and vegetable, then existing upon its surface, and that a completely new creation followed this violent disturbance in nature. This theory of successive destructions and re-creations, as it were, finds favour with those who adhere to the literal interpretation of the Book of Genesis, and the *last* creation they believe to have been the one referred to in the first chapter of that book. On the other hand, there are those who believe that nature has been pursuing a steady and uninterrupted course for ages of ages, and that, with the exception of local eruptions, earthquakes, and deluges, such as we have known within the historic period, the changes in its surface have been the result of gradual depositions in its seas and lakes, and the slow subsidence and upheaval of its continents and islands. These observers believe that there has never been a decided break in the development of the vegetable and animal kingdoms, but that, affected by various causes, such as changes in climate and the conditions of the surface, they have gone on improving, not in the sense of becoming perfect, for all plants and animals have been perfect in their adaptation to the external world by which they were surrounded, but rising in the variety and complexity of their organs and functions.

Then again, such of our readers as have been induced to take a deeper interest in these questions, will know that amongst the advocates of the theory of gradual development, there are some who believe that *each new species* has been a distinct creation, that is, the result of a direct miraculous

* "The Past and Present Life of the Globe." By David Page, F.G.S. William Blackwood & Sons.

interposition of the hand of Providence, which has from time to time, in accordance with the changing conditions of the earth's surface, and a preconceived design, created new types of animals known to us as *species;* whilst others are of opinion that no such interposition has taken place, but that through the operation of an unknown law, one species has been converted into another, and a higher one, during the development of the *embryo* of individuals; and a third set of observers, following the doctrines of Mr. Darwin, attribute the variation of species to *external* physical causes, namely, they believe that it is owing to the capacity possessed by some individuals, of adapting themselves to the changing physical conditions by which they were surrounded. This capability is believed to have arisen from some accidental modification in their external or internal structure, not of sufficient value in any one individual to mark it as a distinct species or even variety, but a peculiarity which, accumulating in succeeding generations, caused the possessors at length to assume a different type, and become *first specifically,* and at length *generically* distinct from their ancestors. Such animals as did not possess these peculiarities that fitted them for the "struggle for existence," naturally died out (according to Mr. Darwin's theory), and gave place to their more fortunate congeners.

As before stated, the theory of repeated destructions and re-creations has been referred to by some theologians, as corroborative of the biblical account of the earth's creation; and now we have to add that the theory of progressive development, *when taken apart from any immediate interposition of the Creator,* has been eagerly seized by the so-called atheists, as evidence in favour of *their* tenets. It is, therefore, not to be wondered at, if the discussion of these opposite theories should often have been conducted in an uncharitable spirit, certainly, however, without the slightest show of justice or reason; for a reference to the opinions of naturalists reveals the fact that they have been held quite irrespective of theological belief; some, whose views are materialistic, still advocating the theory of repeated cataclysms; whilst many who are in other respects completely orthodox, are to be found amongst the strenuous partisans of the theory of progressive development through secondary causes. The majority of good and thoughtful men, however, are beginning to regard the question from a different point of view, and to bestow upon it their dispassionate attention.

Divested of all its exaggerated features, the history of the past and present life of the globe is full of romantic interest and instructive lessons; and instead of serving, as it has done, as a bugbear to the ignorant, and a bone of contention to rival theologians, it is in reality one of the most important problems presented by the Deity for the exercise of man's noblest faculties, and as such we recommend it to the consideration of our readers.

Mr. Page's book leads the novice (or even the well-informed reader) through the present life of the globe back into the distant past, and, in comparatively speaking popular language, relates its story up to the historic era.

He never wanders into speculations, nor does he, on the other hand, leave out of account the most recent and still-debated discoveries; indeed, as long as his account is *narrative,* he is, as he wishes to be, faithful to the task he has undertaken, and has fulfilled it in an accurate, agreeable, and reverent spirit.

Although equally desirous to be unbiassed in his review of the opinions of others, he is here not so successful; for whilst he lays it down as his opinion that all earnest thinkers are not only entitled to a fair hearing, but that without the expression of their varied theories and even hypotheses, we should never arrive at the truth; and whilst, in one place, he declares that "science has its own line and limit of inquiry" (irrespective of theological belief), yet, in another part, where his views are at variance with those of other inquirers, he cannot refrain from stigmatizing the latter as "materialistic," and censures them for not introducing the religious element into their investigations!

We merely mention this as a proof how difficult it is, even for those who do not wish to be regarded as partisans, to lay aside the theological *animus*, and as an example to be avoided by those who approach the subject with a wish to derive full benefit from their inquiries.

On the whole, however, the author deals with the subject in a fair and impartial manner, and we recommend all who desire, without much effort or expenditure of time, to become acquainted with the history of the globe and its living denizens so far as it is at present known, to consult the pages of this able and interesting work.

They will find its *style* popular, the more abstruse technical terms being in every needful case explained; the *illustrations* accurate, artistically drawn, and well engraved; the *type* clear, and free from errors, agreeable to read, and in harmony with the other adjuncts of the volume.

A GOSSIP ABOUT DOGS.*

BY E. JESSE, F.L.S.

WHO will not be interested to hear fresh tidings concerning man's faithful companion amongst the lower animals? Every housekeeper, every sportsman, every child, knows his worth and can afford him a share of his affection.

The propensity which dogs have to attach themselves to man is a remarkable circumstance in the character of this animal. Poverty, sickness, absence, and even unkindness and neglect, do not diminish the love and fidelity of the poor dog to his master. When Stanislaus, the unfortunate king of Poland, was writing to his daughter, he told her that Tristan, his companion in misfortune, licked his feet, thus showing that he had still one friend (his dog) who stuck to him in his adversity. Sir Walter Scott said that he would believe anything of a dog, and indeed their sagacity, extraordinary aptitude in learning not only tricks but to obey the wishes of their masters, their fidelity, courage, and watchfulness, fully entitle them to this compliment. That some dogs have greater sense and qualities differing from others need not be doubted. Some will learn readily—others not at all. Let us give an instance of this. A lady had a pretty spaniel. She tried repeatedly and indefatigably to teach him to beg, but all her efforts were in vain. One day her cat,

* "House Dogs and Sporting Dogs," by John Meyrick. Van Voorst.

which was apparently asleep on her rug near her, placed herself by the side of her stupid dog, and showed him what he was required to do by begging herself. Here was sense contrasted with a want of intelligence. This is a curious anecdote, and it is a perfectly true one.

The book before us contains more useful hints for the management of dogs, both in the field, the house, or the kennel, than any similar work we have yet met with. It contains also some interesting facts on dog-stealing, which may be of use to those who may chance to lose one of these faithful animals.

It would appear that the most careful watching on the part of the owner will scarcely prevent a dog being stolen in the streets of London. If he takes his eyes off his dog for a moment, he finds that it has disappeared, and in this way. Two thieves are in league. One walks about fifty paces ahead of the owner of the dog, and drops small pieces of boiled liver called "duff." The dog naturally lags behind his master to eat it, when the second thief, generally dressed as a respectable mechanic, with an apron, catches him quickly up, covers him with his apron, and coolly walks by the owner, who, when he misses the dog, never dreams of suspecting anyone who is not running away.

A dog is not safe from dog-stealers even if he wears a chain and collar, if he is intrusted to a careless person. A gentleman had a valuable dog, which had been twice stolen and brought back, and which his master determined never to trust out of the house again without a chain. He was one day, however, sent out to walk with an Irish servant, who came back without him, declaring that the dog had slipped his head through the collar when he was not looking. The dog was in a few days brought back, and his master again ransomed him, making it a condition of his doing so that the thief should tell him how the dog had been stolen. It then appeared that his servant had stopped to look at some of his countrymen mending the street, and, while so doing, one thief had held the dog's chain with one hand to imitate the pulling of the dog, while with the other he undid his collar, wrapped him in his coat, and then pointing to his companion, who ran away, he told the servant that the fellow had just stolen his dog, who, of course, pursued him, leaving the animal in the possession of the other.

The writer of this article had a favourite terrier called "Peter." He brought him with him to a house he had taken in Lower Berkeley Street, Portman Square, in a close carriage, the dog never having been in London before. While the servant was unloading the carriage the dog was missed, and nothing heard of him for more than a fortnight, although handbills were circulated offering a reward for him. At the end of that time the dog rushed into the house, jumped up to his master, and showed every sign of joy. He, however, looked thin and starved, and had a piece of cord attached to his collar. He had evidently escaped from the dog-stealers, but how he found his way back to a house he could only have been in for a moment is not easily to be accounted for.

Perhaps amongst the different breeds of dogs, the Scotch colley, or sheep dog, bears away the palm, whether for intelligence, patience, or fidelity. For instance a colley in the Highlands of Scotland was left in the solitary charge of a flock of sheep, which were feeding in a field separated only by a ruined

wall, full of wide gaps, from a field of young corn. The dog had for some time taken his stand on a hillock, from whence he could overlook the whole field, and check any attempt of the sheep to intrude on the cornfield. He remained patiently and watchfully at his post from the earliest dawn to nightfall, and brought the flock home in the evening on hearing the shrill whistle of his master, who lived nearly a mile off. Must we not admire the extraordinary intelligence and the strict sense of duty shown by this faithful animal?

We might multiply similar examples to a great extent; but let us conclude this notice of the colley, by supposing him to have been the constant companion of some old shepherd through many a weary day of rain and frost and snow, on the neighbouring hills, gathering the scattered flock with persevering industry, and receiving the reward of his exertions in the approbation of his master. On returning to the humble cottage at night, he partakes of the "shepherd's scanty fare," and then, coiled up before the flickering light of a few collected sticks, cold and shivering with wet, he awakes to greet his master at the first glimmering of morn, and is ready to renew his toils. Poor dog!—it is impossible not to love and admire you.

But we have not space to enumerate the different breeds or varieties of dogs. Our author notices very many of them; but the chief value of his book consists in his hints for the proper management, training, and breeding of them. In these respects the work is invaluable, and also his receipts for curing or preventing the diseases to which dogs are liable; we can, therefore, safely recommend Mr. Meyrick's work to the attention of our readers, feeling sure that it will equally gratify and instruct them.

The work is nicely got up, the *type* clear and pleasant to read, and the *binding* plain and strong. Of the *illustrations* we can say nothing, for they are "conspicuous by their absence," a circumstance to be regretted, for a few good woodcuts of the various breeds would have added considerably to the interest of the work.

We cannot close this notice without expressing our obligation to Mr. Van Voorst for his great exertions in the cause of natural history; for he has done as much to promote its progress as the able authors who have addressed the world through his medium. Who can forget Yarrell's "British Birds and Fishes," Bell's "British Quadrupeds and Reptiles," Forbes's "British Starfishes," Selby's "Forest Trees," and Newman's "Ferns and Insects"? These, with many others, too numerous to be mentioned, will remain as mementos of his successful labours as a publisher long after he has passed from amongst men. We could say much more in his praise, and we feel sure that these few words of recognition will meet with a hearty sympathy amongst our readers, to whom his excellent works are known.

Chemical History of a Candle. By PROFESSOR FARADAY. Edited by WILLIAM CROOKES, F.C.S. Griffin & Co.

Intended for young beginners, for whom it is well adapted, as an introduction to the study of chemistry.

Practical Chemistry. By J. E. BOWMAN, F.C.S. Edited by C. L. BLOXAM. Longman.

This book is, strictly speaking, a "Manual of Chemical Analysis," and not a work on "Practical Chemistry." It is suitable for teachers, who will find it valuable in the preparation of lectures. Those who wish to employ it for self-tuition will only be able to avail themselves of the first and second parts for that purpose.

Iron: its History, Properties, and Processes of Manufacture. By WILLIAM FAIRBAIRN, C.E. &c. Black.

Professor Hunt's paper on "Iron and Steel," in the present number, may serve as an introduction to this useful little volume. Although of a somewhat technical character, it is by no means dry reading, is well illustrated, and contains a large amount of valuable information concerning the most useful metal employed by man.

In-door Plants, and how to grow them. By E. A. MALING. Smith, Elder, & Co.

Ladies of taste, who desire to adorn their homes with the beautiful productions of nature, will find this little book useful in aiding them to do so at a small cost.

Wild Flowers worth Notice. By MRS. LANKESTER. With Illustrations by J. E. Sowerby. Hardwicke.

Mrs. Lankester has produced a volume which will be found of service to young beginners in the study of botany; and Mr. Sowerby has rendered it most attractive by his well-executed illustrations. One feature of special interest is the information which it contains on the uses, as well as on the distinguishing features of the plants described.

British Birds' Eggs and Nests, popularly described. By REV. J. C. ATKINSON. With Coloured Illustrations by W. S. Coleman (accompanied by a "Synoptical Table of British Breeding-Birds, Nests, and Eggs"—323 in number). Routledge.

An elegant volume, very beautifully illustrated—will be appreciated by collectors of birds' eggs, and may be read with profit by those who desire to know something of the ornithology of this country. But the style is defective, and, we regret to say, somewhat characteristic of the careless one which very many of the scientific writers of the day consider themselves licensed to adopt.

Sea-Side Divinity. By the REV. ROBERT W. FRASER, M.A. Illustrated by Humphreys, Wolf, Andrews, &c. Hogg & Sons.

Is *not* a collection of sermons as the title would indicate; but a business-like account of the geology, botany, zoology, and meteorology of the shores of Great Britain.

Lectures on Natural History. By E. Jesse, F.L.S. L. Booth.

This little book is what Mr. Jesse no doubt intended it to be—a gossip on several subjects connected with natural history. It is published with a very praiseworthy object, viz., for the benefit of the Brighton Sailors' Home, and deserves a large sale. Young persons of both sexes will find it very interesting.

Marvels of Pond-Life. By H. J. Slack, F.G.S. Groombridge.

"Is intended to be no more than an introduction to an agreeable branch of microscopical study," and as such, will interest many who go in search of animalculæ.

Works of this kind are now so plentiful, that it is time for popular microscopists to employ their pen in the description of one or two forms at a time; illustrating it with accurate drawings of the detailed structure of the objects described, instead of grouping together a large number in one small volume, and repeating what has been said concerning them fifty times before.

We do not say this to disparage Mr. Slack's efforts, but to show him how we think he could make them more acceptable to the general reader. The work is nicely got up, and the illustrations are very creditable to the lady who has executed them.

MISCELLANEA.

THE LIVERPOOL AND MANCHESTER FIELD NATURALISTS' SOCIETIES.

IT would be difficult to decide which of the two is effecting the greatest amount of good—the "Manchester Field Naturalists' Society," or the "Liverpool Naturalists' Field Club."

Neither has yet terminated the second year of its existence, and already the Manchester Society numbers over 400 members, whilst the Liverpool Club boasts of considerably more than 500. One of the chief causes of their rapid rise and great popularity is the admission of lady members to all their meetings, whether in the open air or in the lecture-hall.

We cannot, in this our first notice, treat in detail of the operations of the societies, but the salient features will be gathered from the following narrative of a meeting which took place by arrangement between the members of the two clubs, at a fine old ruin called Hoghton Tower, near Preston, Lancashire, on Saturday, July 20th. On this occasion, the weather being fine at Liverpool and rainy at Manchester, about 300 members and friends constituted the party from the former place, whilst scarcely more than 40 persons (the most zealous workers, of course) set out from Manchester, and both parties arrived at the rendezvous at about three o'clock in the afternoon.

Here the weather was beautiful, though at first a little dull, but by the time that the leaders of the two societies had exchanged courtesies on the slope of the hill, the sun shone warm and bright, and the atmosphere became as calm and transparent as could be desired. After enjoying the view from the Tower, and some botanizing in the woods behind and below it, on the part of the ladies and a few gentlemen, led by Mr. Grindon, the honorary secretary of the Manchester Field Naturalists, the whole party assembled for tea, the leaders of the Liverpool Club—Rev. H. H. Higgins, M.A., and Rev. William Bannister—having kindly remained to see that all preparations were duly completed. Tea concluded, all who felt so disposed adjourned to the green slope in front of the Tower, where Mr. Grindon soon drew around him a large company, and proceeded to deliver an address upon the principal plants which had been collected during the day. He stated that it was the custom with the Manchester Field Naturalists always to have such an address by way of impressing the results of the day's researches, and giving an agreeable finish and consolidation to the objects of the excursion. Drawing attention, in the first place, to the *Ferns* which had been gathered, Mr. Grindon showed that most of the large and common species, while in their very young state, so closely resemble mature fronds of small and rarer kinds (except that they are destitute of fructification), that beginners are extremely liable to be deceived by them.

He warned collectors not to suppose that because they had got a lovely *little* fern, it must needs be one of the gems of the fernery, for if placed there, in a short time it would in all likelihood overshadow everything else. Specimens of *Polypodium phegopteris* being handed up, the lecturer remarked that this plant was often supposed, from its name of *Beech*-fern, to be a lover of beechen woods, just as the *P. dryopteris*, or *Oak*-fern, is commonly supposed to be so called by reason of a preference for the shade of oak-trees. Both ideas are mistaken ones. The ferns are respectively named after the two trees because in profile or general outline the individual fronds bear a striking resemblance to the profiles of the beech and oak; so that in those landscape pictures which are often prepared by gumming down mosses, lichens, and ferns, in such a way as to resemble forests and other elements of rural views, these two, the *Phegopteris* and the *Dryopteris*, become striking and ready-made drawings of the respective trees. In the living state, the resemblance of the *Dryopteris* to the oak-tree is somewhat impaired by the deflexion of the central branch, but this is no longer perceived when the frond is laid flat. The *Wild Raspberry* was the next plant noticed. Mr. Grindon commented on the interesting fact that it was probably the only one of our native fruits which in the wild condition has often as good a taste as when cultivated. The apple begins in the crab, the plum begins in the sloe, the cherry in an austere and almost juiceless globule, not larger than a pea; but the raspberry is a raspberry from the commencement. In the woods and cloughs of South Lancashire it is exceedingly abundant, and large quantities of excellent fruit could be collected where the raids of town lads allowed it to ripen. Near Bristol the raspberry is a rare plant; and while walking once in the forest of Meudon, near Paris, the lecturer said he was again struck by the absence of it, made noticeable by the profusion of the wild red-currant, by which the old accustomed fruit was superseded. Describing the *Circæa*, or Enchanter's Nightshade, and some other plants, with names suggestive of classic story, the lecturer pointed out the great variety in the pleasures opened up to all intellects by the study of botany, which was not to be deemed the art of flower-slaughter and excruciating nomenclature, but rather as the "Gate Beautiful" both into nature and into very much of the best portion of poetry, literature, and mythology.

Various specimens, gathered by different members, being placed in Mr. Grindon's hands to be named and described, the lecturer spoke after the same manner respecting the Wild Heath, dwelling especially on a branch of the common heather, or *Calluna vulgaris*, a plant loving great solitudes. He called attention to the vast number of individual blossoms that were crowded together into the small space it offered, and to the pretty arrangement of the minute leaves, which were disposed in such a way as to remind us of some of the patterns of ornamental gold neck-chains. Nothing in art, he said, was absolutely new. However simple, however ingenious or seemingly original, so long as the forms and proportions commended themselves to our perceptions as beautiful and symmetrical, they were always to be found somewhere in nature, which was the storehouse at once of all great ideas and of all choice imagery and designs. Further to illustrate this, the lecturer cited the case of the common Ox-eye Daisy, the centre of which prefigures the crossing curves on the back of an "engine-turned" watch-cover. The same

may be seen in the centre of the China Aster and many other composite flowers.

Rosa canina was next passed under review, and the variety of it formerly distinguished by some botanists as *Rosa Forsteri*, the lecturer taking advantage of the opportunity to point out the distinctions between "species" and "varieties." Much, he remarked, of what he had stated was probably familiar to all the botanists present; but the Societies were established more for the benefit of the unlearned, and the greatest pleasure *he* experienced in life was the passing on to others who were only just entering on scientific inquiries, what he himself had acquired from year to year.

Thus far the proceedings, as we have described them, were characteristic of the *modus operandi* of the Manchester Society. We must now retrace our steps, for an instant, in order to show how the Liverpool Club carries out its objects.

On the arrival of the Liverpool party at Hoghton station, the honorary secretary, the Rev. William Bannister, distributed amongst the ladies a printed list, headed "L. N. F. C. Names of Natural Orders from Dr. Dickinson's 'Flora of Liverpool.'"

This list comprised 101 orders, beginning with "Ranunculaceæ," and ending with "Characeæ," each order being separated from the adjoining ones by perforated lines, so that the greatest facility was afforded for tearing off the names of the orders.

The object of this proceeding was to enable such of the ladies as desired it to compete for the "Botanical Prize" (a book value 10s. 6d.); one of which is awarded at each excursion "to the lady who collects and arranges, according to the natural orders, the largest number of species in flower." Any specimen wrongly marked is rejected, and no lady is entitled to receive more than one excursion prize in the season. The last-named is an excellent regulation, enabling the less advanced botanists also to compete with some chance of success.

By way of parenthesis, we may mention that, beside the excursion prizes, the Liverpool Society grants thirteen others, varying in value from £1. 1s. to £5. These are season prizes, given for the following collections:—The best Hortus Siccus (3); Conchological (1); Geological (1); Microscopical (1); Zoological (2); Entomological (4); General (1).

During their rambles on the occasion in question, many of the ladies were busily occupied in the collection of plants; but, owing to the length of Mr. Grindon's excellent address, the judges, who are usually the two vice-presidents (the Rev. H. H. Higgins and Dr. Collingwood, F.L.S., along with one or more of the committee), were unable to award the prize to the successful competitress. This part of the proceedings was, therefore, postponed.

The same cause also compelled the Rev. Mr. Higgins to curtail his address, which was delivered by him, as the representative of the Liverpool Club, after the conclusion of that of Mr. Grindon. He referred to the general objects and rewards of societies such as those which were now so harmoniously mingling about him; to the beauty of nature, as awakening many of the noblest emotions of our minds, with the result, which scarcely ever fails to follow, of a larger and more religious apprehension of the world

around us; in every way promoting our happiness and genuine enjoyment of life.

The company returned to their respective homes at about eight o'clock; not a single untoward incident having occurred to mar the day's intellectual enjoyment.

REWARDS AND HONOURS FOR PROFICIENCY IN SCIENCE.

THERE is probably not one young man in a thousand who is aware of the fact that if he makes himself acquainted with what every schoolboy should know, and every sensible lad ought to be delighted to learn in connection with almost any branch of science, he may pass a government examination, and receive a certificate, along with a book, or a gold, silver, or bronze medal, as a prize. And moreover, if he prefer rewards of a more substantial character, he may, at the expense of government, travel up to London and remain there during the half-yearly examination: having passed his examination, he may secure an honourable diploma as a teacher, and become entitled to an annuity varying in the aggregate from £10 to £40, if he returns to his native town and there establishes a science class. In addition, he will receive a fee for every pupil who, through his instrumentality, passes a government examination, and obtains a certificate. All these privileges are entirely irrespective of any charge which he may deem proper to make for tuition.

Last, but not least, he may, in following so honourable a profession, effect much good as a teacher of the humbler classes, instead of adding to the host of desultory lecturers who address empty benches in our halls and schoolrooms.

"Ay!" we hear some reader exclaim; "how well all that sounds in theory; but where shall I find the time necessary to prepare for such an examination?"

We will humour the diffidence of such a one, and suppose that his information on scientific subjects is of the most limited kind.

Say, for example, that he has acquired some knowledge in any particular branch of science. Geology, for instance.

Does he think he would be able to answer the following questions; because, if he can do so sensibly, he would, we think, obtain *at least* a third-class certificate, with the accompanying privileges and emoluments.

He need not be nervous or timid; the examiners, men of high attainments, are kind, considerate, and gentlemanly in their demeanour; indeed, they are anxious for his advancement. Moreover, they put their questions into print, and give him ample time to answer in writing.

"What is meant by a fossil?

"Into what two great classes have rocks been divided?

"By what means has the material in stratified rocks been arranged?

"Name some of the different kinds of rocks. (In this question I do not want the names of *formations*, such as Old Red Sandstone, Gault, &c.; but the common geological names of rocks, such as shale, granite, &c.).

"How does coal lie among the strata? and *how was it formed?* and what metallic ore is worked to a great extent in the coal measures?*

"Name any of the genera or species of fossils found in the oldest Tertiary or Eocene rocks.

"Name some of the kinds of fossils found in the Silurian rocks."

Some of the questions in the series are more difficult than those we have extracted; but the replies entitle the student to a higher degree and greater emolument.

Now let us turn for a moment to the subject of Animal Physiology, and inquire what is the nature of the information expected from the candidate in this branch of knowledge.

Here are the first six questions of the first series:—

"1. Of what chemical elements is animal flesh composed?

"2. What are the chief chemical components of bone?

"3. What is meant by 'organs' and 'functions'?

"4. What becomes of a piece of bread when you eat it?

"5. What is the use of saliva?

"6. What is bile, and where is it formed?"

Will any one assert that a person who is unable to answer these questions with ordinary accuracy has received a proper education?

They may be taken as the types of those which have to be answered in the other branches of science; but, of course, we do not recommend any of our readers, who are disposed to avail themselves of the advantages offered by the Science and Art Department, to be content with such elementary knowledge as this. Whilst we only give these examples to show how *little* will enable an industrious man to attain a certain position and earn an honest livelihood, we recommend all who have the time and ability to become as proficient as possible before presenting themselves for examination.

Science forms but a secondary element in the education of our youths, and consequently few teachers in schools have any knowledge on the subject.

These, the teachers, should lose no opportunity to improve themselves in this respect; otherwise, they may rest assured that better-informed competitors in this part of the "labour market" will soon supply their place, for the time is not far distant when a man who is unacquainted with the elements of scientific knowledge will be deemed as ignorant as we now consider one who can neither read nor write.

It therefore behoves the friends of education in every town or large village to second the good work of our government, by the establishment of classes and schools of science.

And now we must be permitted to give a hint to the Committee of Council on Education.

We find a constant repetition of the word "he" in the regulations of the Department, in speaking of teachers and candidates, and venture to suggest that the words "or she" be added; for, until they are, the movement will not be completely successful.

* This is one of the most difficult questions in the series, and its "value" (*i.e.*, the number of marks given for the answer) is a high one.

QUARTERLY RETROSPECT.

As we glance cursorily over the scientific events of the last few months, we cannot help being struck by the growing influence exercised by man over the powers of the universe—an influence whereby these forces are daily rendered more and more subservient to his purposes.

The subject by which our attention is especially arrested is that of *Astronomical Photography.*

Not only does the glorious orb of day, by means of the warmth and light which it imparts, serve to sustain our vitality and that of the numerous tribes of plants and animals that surround us; not alone do its rays illumine all *Nature*, but they have been impressed into the service of *Art*, and are now employed as pencils to delineate and register the phenomena and changes to which the solar orb itself is subject.

At the recent meeting of the British Association for the Advancement of Science, Mr. Warren De la Rue made the following communication to the members:—

"I have obtained some sun-pictures, of very considerable promise, on the extremely large scale of the sun's diameter equal three feet. These pictures have only been very recently procured, and I submit them to the section because I believe that an interest is felt in the progress of celestial photography, and that our members prefer to take part in the experiments, as it were, by watching their progress, rather than to wait until the most favourable results have been brought about. I may state, the mechanical and chemical difficulties have been surmounted, and the only outstanding one is the form of the secondary magnifier. When this has been worked out, perfect sun-pictures, three feet in diameter, will be obtainable with a telescope of one-foot aperture in less than the twentieth of a second of time. These pictures, when taken under suitable circumstances, may be grouped so as to produce stereoscopic pictures, which must throw considerable light on the nature of the spots."

But the enterprising artist of the heavens is not contented with the portraits that *our* sun furnishes of itself: the suns of other systems, with their attendant planets, must shed their lustre on his sensitive tablets, and map themselves to aid him in his studies and his speculations. He thus continues—

"We now know that the luminous prominences which surround the sun, for they do belong to him, can be depicted in from twenty to sixty seconds, on the scale of the sun's diameter equal $\frac{4}{3}$ of the object-glass employed. That is to say, an object glass of three inches aperture will give a picture of the prominences surrounding a moon four inches in diameter.* The next subject I have to call your attention to is the photographic depiction of groups of stars, for example, such as form a constellation like Orion—in other words, the mapping down the stars by means of photography. I have made several experiments in this direction, and have obtained satisfactory results, and I believe that, at last, I have hit upon an expedient which will render this method of mapping stars easy of accomplishment."

Here the *astronomer* leaves the heavenly bodies for the present; but now the chemist "takes up the wondrous tale." Seizing their luminous rays, just released by his brother investigator, he analyzes them, and from their pale light

* This refers to the experiments made by the lecturer on the solar eclipse.

educes all the colours of the rainbow. Nor does he rest here, for by his exquisite tests he is enabled to pursue them to their sources, millions of miles distant, and from the composition of the emitted rays he traces that of the bodies whence they emanate. Soon we shall be fully acquainted with the constitution of the heavenly bodies; shall know of what materials sun and moon and stars are formed!

The history of the recent discoveries connected with the solar and other spectra was ably narrated at the meeting to which we have just referred, by Professor W. A. Miller, of King's College, London; but the subject is deserving of more than a passing notice, and we hope in our next number to be able to present it to our readers in a popular guise.

Let us not, however, quit the photographic art too hastily, for it leads us into other realms of nature. Passing from the inanimate to the animated world, we still find it busily at work.

The "Natural History Review" of last July contained an excellent photograph of the brain of a chimpanzee, in illustration of Mr. Marshall's paper on that subject; and it has been very properly suggested that all works which will admit of it, more especially books of travel, and such as treat of new forms of life, should be thus illustrated as a guarantee for their accuracy.

This is no new idea. Who does not recollect the interest that characterized Mr. Piazzi Smyth's charming work on "Teneriffe," which was not only illustrated by photographs, but was accompanied by a folding stereoscope to aid in their inspection? And now adieu to nature's artist.

The "brain of a chimpanzee" naturally reminds us of the animated discussion which has recently taken place between Professors Owen and Huxley, concerning the cerebral development in man and the higher apes, in which the latter gentleman has sought to show that the difference between the two is not so great as physiologists have hitherto been led to believe. From the chimpanzee we naturally pass to the gorilla and M. du Chaillu.

In the absence of any communication having been published (at least so far as we are aware) from the Rev. Messrs. Wilson and Mackay, missionaries at the Gaboon, to whom, if our memory serves us aright, M. du Chaillu stated he should write for a verification of his narrative, we may say that we have it from an authentic source, that the traveller is well known to those gentlemen. Our informant has often heard him named by them as an adventurous explorer, who had penetrated far into the interior, but never as a naturalist or scientific man. Beyond this we have no desire to comment upon a dispute which has already occupied quite enough of the public attention.*

In regard to the great antiquity of man, it will doubtless have been observed by many of our readers, that the evidences in its favour are daily

* Since the above was written there has appeared in the *Advertiser*, *Athenæum*, &c., a letter from a Mr. R. B. Walker, to whom M. du Chaillu was well known. To a great extent he confirms the accounts we have received concerning him, but also accuses him of gross exaggeration, mendacity, and ignorance. The *Critic*, however, publishes two letters from the same gentleman, dated 1858 and 1859, in which he speaks of M. du Chaillu in very different terms.

gaining new advocates for the theory. The latest convert of importance is, we believe, Sir Roderick Murchison, who, at the recent meeting of the British Association, stated that

"He should not occupy time by alluding to the engrossing subject of the most recent natural operations with which the geologist had to deal, and which connected his labours with those of the ethnologist. On this head he would only say, that, having carefully examined the detrital accumulations forming the ancient banks of the river Somme in France, he was as complete a believer in the commixture in that ancient alluvium of the works of man with the reliquæ of extinct animals as their meritorious discoverer, M. Boucher de Perthes, or as their expounders, Prestwich or Lyell, and others. He might, however, express his gratification in learning that our own country was now affording proofs of similar intermixture, both in Bedfordshire, Lincolnshire, and other counties; and, possibly, at this meeting they might have to record additional evidences on this highly interesting topic."

If, day by day, the telescope is enabling man to penetrate farther and farther into the distant heavens, and chemistry is rendering him cognizant of the constitution of the rolling orbs, so is the penetrating power of the microscope bringing within the range of his vision innumerable objects of beauty hitherto unknown to him, and investing the most commonplace subjects with fresh interest and wonder. Who would have dreamt that a piece of orange-rind could afford us opportunities for the study of entomology? But so it is.

Mr. Richard Beck has imparted new interest to this one of the most ordinary of our imported fruits.

He says (*Micr. Trans.* 47) that, "If the external surface of almost any of the sweet oranges be only cursorily examined, it will be found more or less spotted with small scales, the shields of a 'Coccus' or scale-insect.* They are adherent to the rind of the orange, but can easily be detached; and on turning one of the larger ones over, it will be found, on examination under a low power, to present as the most striking feature a large accumulation of eggs lying beneath a cottony secretion."

Mr. Beck has minutely described the metamorphoses of this curious little insect; and he says that one single orange, if well selected, will supply every condition described by him. Many microscopists will, no doubt, be tempted to direct their attention to an interesting object so easily obtainable.

Every day fresh additions are made to the list of those exquisitely constructed and mysterious microscopical forms the "Diatomaceæ." Several new species have, during the last few months, been described and delineated by Dr. R. K. Greville, Dr. Donkin, and George Norman, Esq.

A few words more in regard to chemical science, and we must draw this imperfect review to a close. The question of the employment of Arsenic in colouring ladies' dresses, head-gear, &c., has caused some stir, and on this subject an obliging correspondent sends us the following communication, which will no doubt be found interesting to our readers:—

"GREEN COLOURS.—Scheele's, or the arsenical, green is in many respects a most objectionable and especially a dangerous colour. Elsner has intro-

* One of the "Hemipterous" order of insects, of which the well-known Aphis may be considered the type; and the family to which the cochineal insect belongs.

duced three new greens, which are very pleasing, and which are certainly not liable to the objections urged against the arsenical preparations.

"*The Elsner Green* is prepared by adding, first, sulphate of copper to a decoction of fustic, and then about ten per cent. of protochloride of tin. To this is poured an excess of caustic soda, whereupon a green precipitate falls. This, on being washed and dried, assumes a peculiar but pleasing *blue-green colour.*

"*Tin-copper Green.*—Fifty-nine parts of tin are heated in a crucible with one hundred parts of nitrate of soda. This is dissolved when cold in caustic alkali. The solution, being diluted with water and allowed to clear, is united with a solution of sulphate of copper. A reddish-yellow precipitate falls, which, on being washed and dried, becomes a very beautiful green.

"*Titanium Green.*—Titaniferous iron is fused with twelve times its weight of sulphate of potash. The fused mass is treated with hydrochloric acid, heated to 50° Cent. and filtered hot. The fluid is evaporated until a drop placed on a glass-plate solidifies. A concentrated solution of sal-ammoniac is poured over the mass, which is stirred and filtered. Titanic acid remains behind; this is digested with dilute hydrochloric acid, and, a solution of prussiate of potash being added, the mixture is heated to boiling as quickly as possible. A green precipitate falls, which must be washed with water acidulated with hydrochloric acid and dried at a temperature under 100° Cent. The result is a beautiful dark-green powder."

And now we must for the present bid farewell to the reader. Our anxiety to allot as much space as possible in this, our first number, to correspondents for the insertion of instructive articles has necessarily compelled us to curtail our quarterly gossip on scientific events, and in so doing we trust that we have secured the approval of our readers, to whom we shall at all times endeavour to afford the greatest possible amount of interesting and instructive information.

CAVERNS AND THEIR CONTENTS.

BY D. T. ANSTED, F.R.S.

CHAPTER I.

THE CAVERNS.

ONE of the great charms of a wild ramble by the sea-side, where the cliffs and the waves occasionally meet, and where the tidal action is powerful enough to produce a marked impression on the form of the shore, is, that we are thus constantly presented with varied broken outlines whose picturesqueness depends on rock, wind, and weather. But within these outlines are frequently deeper recesses, more or less concealed, more or less difficult of access, more or less occupied by animal or vegetable life, or the remains of such life, and into their cavernous recesses one is always tempted to penetrate, for in them we rarely fail to find grand and simple forms:—rocky vaults arched according to some fantastic plan of Nature's own device; sepulchres yielding occasionally bones of very ancient lords of the soil, and collections of living animals of low organization, especially interesting because capable of being observed under natural conditions.

Few rocks so situated on a bold coast are without caverns; but there are two large and very easily recognized kinds of material in which caverns chiefly occur. These are granite and limestone. The best caverns in every respect are in one or other of these rocks; but they vary in their nature, origin, and history, to a remarkable extent.

The first commencement of almost all caverns may generally be traced either to mechanical disturbance connected with the upheaval of rocks formed at great depth, and subsequently brought to their present position, near the surface of the earth, or else to that contraction which has of necessity taken place when materials deposited in and with water have solidified, parting with their water, and contracting into a smaller space, as they ceased to be mud and became compact rock.

Cracks and fissures, either originally open, or closed almost as soon as formed by the introduction of mineral substances, that decompose on exposure to weather more rapidly than the rocks enclosing them, are thus the fertile causes of most of those innumerable natural holes and fastnesses of which poets

sing and which artists love to represent. Varying in their origin according to the nature of the rock they lay open for our inspection, and indicating the history and progress of the changes they have undergone before arriving at their present state, they have a special interest for the geologist; and it is astonishing how completely geological points regulate also their value and interest to the naturalist, the artist, and the mere seeker after adventure and picturesque scenery.

First let us consider the case of caverns in those noble old granites and porphyries, those gneissic rocks, those slates, and those basaltic and volcanic regions where the battle is ever going on between the dash of the wave and the tough fibre of a hard rock. It is a battle that can end only in one way, for, unlike all human contests, in which both sides suffer, the water, however often beaten back, always comes again to the charge unweakened by the effort—it always finds at last the weak point in the enemy's armour—each time it succeeds in removing a few grains or fragments, it enlists these as recruits to bring away more—and thus it advances steadily if stealthily—surely if slowly—"here a little and there a little," until very often it is enabled to act on a larger scale and assume a more important attitude of offence.

Look at the "iron-bound" shores of the Atlantic on the European side. Take any part of this extended line where the granite is firmest and the porphyry toughest. How do we find these rocks? Many of the hardest are islands, already detached from the main land, many others are headlands and promontories. Between them and amongst them are lovely little bays with sandy and rocky beaches. The cliffs exposed are hoary enough to look at, and covered with lichens. But what mean the angular blocks of stone on the beach? Whence came those vast fallen masses almost like islands, at the foot of the cliff? The question is easily answered. They have fallen from above. The cliff has been undermined, the ruin and destruction of the whole mass long ago commenced, and there is no longer any question but that of the time that will be required to complete the work.

The study of a single island, or even part of an island, is very instructive, and the account of a single group of caverns will be more satisfactory than a long description of varied disturbance.

There is in the English Channel a wonderful little island, three miles long, and a mile and a half across at the widest part, entirely surrounded by steep cliffs, some 250 or 300 feet high, the whole of which, without exception, are composed of granitic and porphyritic rock. One would say, looking at the walls of rock surrounding it, that the waves, angry and

powerful as they might be, would here have little effect. They must beat against this granite in vain. Except here and there, where a soft vein occurs, the rock is all hard. There is no mixture of modern water-deposited limestone or sandstone—no beds of yielding clay and treacherous sand—no loose rocks or decomposable material. All is granite, or hornstone, or porphyry, or some of those other rocks recognized by geologists as among the most indestructible. But what is the fact? Of all places within easy access there is none like Sark for caverns—nowhere is the history of the origin and enlargement of one great class of caverns more manifest—nowhere is granite more clearly the slave of water, performing all its behests, helping to subjugate completely the very class of rocks to which it belongs, the broken rocks themselves working incessantly and actively with the waves, helping to tear into shreds and carry away as mud and sand all that is hardest and most durable.

Caverns in granite are generally water-worn from without, or, in other words, the mechanical force of the waves is greater than the dissolving and chemical action of fresh water percolating the rocks. Always, no doubt, a solvent, the effect of water in this respect on rocks which contain but little alkaline earths is comparatively small; but, on the other hand, such rocks, having been originally formed at high temperature and cooled down, have cracked, and the cracks have become filled with various mineral substances, often decomposing more or less readily than the rock. It is not difficult to understand that the effect of this difference of condition must involve a partial and irregular destruction of the rock. The softer part being removed, the harder part falls down, and thus we have those never-ceasing little bays, creeks, and inlets, those wonderful *voes* and *fiords*, and other variously named irregularities of the coast-line, which greatly contribute to the wildness and grandeur of granite coast scenery.

And thus also we have caverns formed. On that part of a group of hard rocks that is softer than the rest, the water first acts. It beats vehemently against the rock with a force sometimes of many pounds on the square inch. On an exposed coast blocks of stone weighing two or three tons, and presenting more than eight or ten square feet of surface, are lifted up and carried over obstacles to a great distance. Smaller stones are rolled about and hammered against each other, and against every weak place in the cliff. After a time, the weak place is hollowed out, and an open cave is the result. Two or three veins, parallel to each other, are acted on in this way, perhaps at the same time, and an entry is made. The commencement of a tunnel is driven, a tunnel that shall connect

the waters of adjoining bays, just as that now in progress through the Mont Cenis will connect France with Italy. Neither operation is work that shows much advance from year to year, but of both the result is sure. Great systems of veins, parallel and at right angles to each other, are acted upon, and the tunnel creeps on. At the same time, perhaps, a little rill of water insidiously makes its way from above, finding some means of coming down to the sea below. Very soon does the sea take advantage of this slight help. It is the mouse gnawing the meshes of the net that holds the lion. A part of the ground above falls in, and either a rapid slide of part of the cliff, or a gradual and periodical fall of the roof, gives the sea something to remove, and supplies fresh hammers wherewith to beat at the outer gate. The cavern enlarges as the walls and roof recede,—falling to the floor, and removed thence by the waves.

Thus have been formed those magnificent caverns in Sark, called "Les Boutiques," than which few things are finer; thus, also, were formed the "Gouliot" caves in the same island.

The walls of such caverns are generally bare and smooth—worn so by the constant trituration of small stones conveyed by the sea. They are sometimes also deeply furrowed with fissures, not yet expanded. It is only where the tide rises and falls many yards that such results are seen on a grand scale; but according to the extent of force exerted, so will be the destruction.

Large caverns that enter far into the land, whose floors were originally level with the sea, become by degrees altered in this respect, when the roof falls in faster than the sea is able to grind up and remove the fragments. Then we often have one access to the cavern half-way down a steep face of rock, and the floor rises until at last there is a mere open cleft above, and no more roof remains to fall. The cavern is then open to the sky, and is a kind of natural chimney. The work of the sea, however, goes on steadily from below, and at last the fallen fragments are removed: the gap or chimney then enlarges, the cavern at last ceases to exist, and what was once part of the mainland, forming the wall of the cavern seawards, is now a rocky islet, soon probably to be removed altogether.

The picturesque effects seen in the neighbourhood of such caverns are numerous and very fine. Detached rocks, pierced by natural arches—rocks connected with each other by natural flying-bridges—pinnacles and pyramids of naked rock, looking like huge artificial monoliths—all these are common. Not unfrequently, where circumstances admit, the rocks are clothed above with terrestrial green; below with brown and black marine incrustations of sea-weed, and in the middle they are grey with

lichens;—the whole mass standing forth from a bold coast, and rising out of deep water, which becomes white with foam as it heaves and breaks upon the obstacles that lie in its way.

When caves are shallow, and mere semi-vaulted recesses, the dark shadows they present are always simple, but often effective, contrasting with the more broadly-lighted sides of the cliff. When they enter further into the cliff, the view from the mouth of the cavern, looking outwards, is very grand. When they bend, and the light of day is partly lost, there is a strange pleasure in feeling one's way to the end, enjoying the fresh sea smell from the waters, but lately retired, and hearing the distant boom of the waves, whose sound is reflected from the hollow vault beyond. Often the artist is able to obtain peculiar and highly-picturesque effects from the vicinity of isolated peaks of rock near the mouths of such caverns, and not unfrequently there is a certain amount of difficulty experienced in the entry and approach, but this only enhances the pleasure of exploring, and insures quiet and undisturbed possession.

Rarely, but still occasionally, it happens that these granite caverns are very extensive, and consist of many chambers opening one into another, and difficult of access. Crevices very narrow, but extending vertically to great height, connect openings of some magnitude. Such caverns can only be visited with artificial light, and involve some climbing and scrambling.

The contents of caverns in granite are generally confined to living limpets, sea-anemones and sea-weed sticking to the rocks, and pebbles and sand covering the floor. Many of them are remarkably rich in marine animals, but of all that have been explored none can approach the Sark caverns called the Gouliots. These very remarkable vaulted recesses are situated on the side of Sark next to Guernsey. They are the modern representatives of a succession of somewhat similar caves, the final laying open and destruction of which has caused the separation, first of the island of Brechou, and more recently of the intermediate Gouliot rock from the island of Sark. There is a wide space of cavern-floor left dry in these recesses at extreme low tides, but the caves may be visited partially, and with difficulty, at ordinary low water. The space occupied by these openings is separated into compartments by bold and grotesque arches, each compartment being the habitation of some marvellous group of marine animals. Here, owing to a combination of circumstances, there may be seen animals living and flourishing, and exposed to view, which, under ordinary conditions, require several fathoms of sea-water over them. It is a natural marine aquarium on the grandest scale, compared with which all other collections of marine animals are mere toys.

Slate caverns and sandstone caverns are different from those in granite, but the difference chiefly arises from the characteristic way in which the rock weathers. Slates present sharp lines, jagged edges, and square forms, which are retained in the caverns formed within them by the sea. In slate as in granite, the wearing away is chiefly from soft veins, and, owing to the material, it is not often that the extent is great, or the cavern tortuous or complicated.

Sandstone is rarely so hard and compact as to form a good material for caverns, and in its pure state it resists the action of water so completely that no effects are produced but those strictly mechanical. It also rarely contains systematic veins of softer material, so that although a sandstone coast-line is often extremely wild, bold, and jagged, it does not often present fine caverns. There are, however, grand exceptions, as on the south coast of Ireland, and elsewhere. In these cases arched rocks are not unfrequent, the sea undermining the stone chiefly in the planes of bedding, and entering far into the recesses of the rock before the roof falls in, and the cavern becomes a cleft. Sandstone caves may be covered with limpets and barnacles, but are not often rich in the more beautiful varieties of animal life and sea-weed.

Some wonderfully picturesque and grand caves are found connected with modern lava, and also with those ancient lava currents called basalt. The great basaltic district of the Giant's Causeway in Ireland, and the coast of the opposite islands of Scotland, are penetrated by caverns, which have often been described. Fingal's Cave is one of the best known in the British islands. Similar caves or grottos on a smaller scale are known on the banks of the Rhine, not far from Bonn; and others, again, in Italy and the various volcanic districts of Europe. The sea has had but little to do with these: they are dependent partly on the mode in which the columnar masses were originally formed, and partly on the kind of decomposition to which they are subjected.

As a wonderful contrast to these dark fire-developed recesses, these gloomy and majestic halls of Pluto, we may just allude to the brilliantly-lighted ice caverns, frequently formed in glaciers, though not often visitable by man. Nothing can be conceived more beautiful than the colour transmitted through ice, and nowhere can this be seen in perfection but in one of these caverns. The river of cold water that has formed the cavern rushes along at one's feet—the only disturbance to the dead stillness that otherwise prevails. Here is no life, no mark of life to be traced; but there is occasionally a floor of broken fragments of rock, torn away by the action of the cold that has originated the glacier in the thin air of the mountain-top.

But there is another great class of caverns very different from any of these. Limestone, like granite, is a brittle rock. It is, however, softer than granite, and is chemically acted on by water, both more rapidly and more completely. Thus, not only by the sea-side and within the action of the tidal wave, but in every place where there is a continuous mass of limestone compact enough to hold together, there are numerous crevices in the rock arising originally from fracture or contraction, and increased during elevation, but finally enlarged and converted into caverns by water.

In England such caverns occur in the compact limestones of the coast of South Wales, in many parts of North and South Devon, in Derbyshire, and in Yorkshire. In France and Belgium many others might be cited; in Central Germany there is a well-known and remarkable district honeycombed to a marvellous extent by them, while in Carniola the caverns of Adelsberg, in Greece a multitude of grottos sacred in classic story, and in America the Mammoth caverns of Kentucky, may be mentioned rather as a few examples selected at random from a countless host, than as giving any outline even of the chief localities of such phenomena. So frequent, indeed, are caverns in some kinds of limestone, that their absence, rather than their presence, is remarkable. But, on the other hand, there are some limestones that seldom contain them. Such are the Portland stone and some of the other oolites of the British islands, although corresponding rocks in other countries abound with them. Such, also, is chalk, which is too soft to admit of large halls and intricate passages, although noble vaults receding from the sea are not unknown.

Limestone caverns, commencing from or terminating in sea-side cliffs, close to the ordinary sea level, are not on the whole the most common. In this respect, therefore, they vary essentially from those in granite, and the picturesque effects obtained from them are also very different. Much more frequently they open out on cliffs or escarped faces of rock, far away from the sea; often, indeed, in river banks, but even then at levels far above the present water-line. Their openings, again, are not always large in proportion to the size of the cavern, nor have the entrances of important caverns of this kind any relation to the magnitude and extent of what is within. In all these respects they have their own marked peculiarities, and these depend partly on original formation, and partly on subsequent and long-continued wearing by running water.

Water-action, in the case of these great open spaces within limestone rock, is a force that requires explanation; for, although the result is clear enough, the exact course of proceeding is less manifest.

A mass—originally, perhaps, a pulpy mass of lime-sand, and clayey mud—is formed under water, and afterwards covered with other deposits. Exposed in this way to the influence of certain forces within the earth, it parts with much of its water, and the particles become compacted and often half crystalline. It retains, however, its character of a number of parallel beds and strata lying one above another. When such a mass, well hardened, comes to the earth's surface, and above the water-level, it is inevitably cracked and broken, some of the cracks being wide and open, and others narrow and scarcely perceptible. Once at the surface, all these crevices become water-channels, and some hill-side at a distance bleeds with innumerable little streamlets, the result of rain falling on the earth, and penetrating below the vegetation and the soil into these crevices, and so through the mass of the rock. But water thus entering limestone contains carbonic acid, having passed through the atmosphere after distillation in Nature's great alembic in the clouds, and water under such circumstances freely takes up a certain portion of calcareous matter. Every drop that falls, then, removes its particles, and the narrow fissure, through which at first the trickling water could barely find its way, is soon enlarged, and becomes a watercourse. At frequent intervals, the water reaches a bed of soft slimy mud, often found between two regular limestone strata, and its progress is then for the time interfered with. It now acts mechanically as well as chemically, and scoops out a space that, under favourable conditions, becomes itself a cavern. Forced to find its way occasionally between hard material, not favourably circumstanced for mechanical action, and then suddenly reaching softer parts of the rock, a succession of chambers is formed, which communicate, indeed, with each other, but only by very narrow crevices. Thus it arises that limestone caverns are almost always both well ventilated and wet, and generally difficult of access.

But other results are obtained from this origin. Water drips constantly through caverns once formed; it often carries along with it a certain amount of fine mud, and, as it goes on, becomes charged with as much carbonate of lime in solution as it is able to hold. Whenever the water passes over a level surface, some of the mud is deposited, and whenever the draught of air that passes through the whole series of chambers is dry enough to admit of it, part of the dropping, or dropped water in the cavities evaporates, leaving behind a film of limestone previously held in solution. In this respect, limestone caverns are entirely different from others, for the walls and floor, instead of being only mechanically worn by the rubbing of the water, are first eaten away by its solvent power, and then one part

becomes coated with a deposit removed from another part. In the course of time it will happen, under circumstances favourable for their formation, that the whole of a large district of limestone rock becomes so completely intersected by passages and chambers, and these are so affected by the removal of the surface in some places by chemical action, the wearing in other places by mechanical action, and the renovation everywhere by the deposit of successive films of limestone, as to give an appearance of artificial construction of the most complicated kind.

The deposit of successive films of limestone is generally very systematic. It produces three distinct appearances, which we may describe as stalactites, stalagmitic masses, and stalagmitic beds or strata.

Stalactites are the drooping pendants and curtains that depend from the roofs of limestone caverns. Wonderfully beautiful and picturesque are they, when seen, undimmed by smoke and dirt, in caverns that have not yet become celebrated, or in parts of large caverns rarely visited. Marvellous forms, the precise cause of which it seems almost impossible to trace, excite the imagination and suggest resemblances to all kinds of familiar and unfamiliar objects. The simplest of all are the grouped cylinders and cones of transparent cream-coloured stone, thousands of which, sometimes detached and sometimes touching each other, mark where there have been crevices through which water has oozed. When a number of drops have fallen from an extended line, a curtain is formed, with occasional fringes of the same stone. Where there have been drops long falling from a point where the drip is continuous, the pendant is on a grand scale, it grows downwards rapidly, it assumes large proportions, and becomes part of a columnar mass. Meanwhile, the whole of the water has not been got rid of at the roof, but a part has fallen to the floor and evaporated there. A base has been formed below, while the capital of the column was being traced out above. As the slender shell of stone, at first not thicker than the film that gives colour to a soap-bubble, assumes by degrees larger proportions, many drops combining in one spot, and all together tending to produce an inverted cone suspended from the roof, so in the same way does the work go on below—enlarging and spreading out, and, at the same time, rising in a conical form, until at last the two portions meet, point to point, and the column becomes complete. Sheets or curtains of stone, gradually thickening, but remaining translucent, are occasionally formed by a number of columns touching each other. These sometimes serve as walls, separating into compartments the chambers in which they are formed, and not unfrequently we meet with fantastic masses

of stalactite, more or less resembling tables, altars, organs, and other objects, named according to the taste of guides, rather than from any real or traceable resemblance.

In such limestone caverns, the smallest chambers, and often very minute subdivisions of them, are characterized by these curious accumulations quite as much as the great halls. Commencing with the lifting up of the limestone mass in its hardened state, the cracking of the surface, and the first infiltration of rain-water, the construction of ordinary stalactites and stalagmites in caverns has gone on unchecked, being guided only by the accidental course of the fissures and crevices. But there is another kind of deposit within these limestone vaults which is also interesting, and on which much depends. It is the flat floor that is commonly noticeable, especially in the chambers near the outlet, and that is independent, to some extent, of the stalagmitic base of columns. This floor is composed partly of an impalpable mud containing iron ochre, and has been derived from foreign material carried in by the water from above, or drifted in from some side entrance. From time to time, a coating of stalagmite, nearly horizontal, has formed on the surface of the mud, separating the floors of different periods of the cavern's history, and enabling us to judge of the comparative date of any foreign objects found buried. Many such coats succeed each other at intervals, and fragments of old stalactite and stalagmite are often confusedly mixed up with the mud of the floor, and re-cemented.

This brings us to the second part of the history of caverns, which we must reserve for another chapter. It will there be shown that, connected with the mechanical facts we have been describing, there is associated a group of natural-history facts of the most singular kind, pointing to conclusions with reference to organic life, and even to the history of the human race, not surpassed in interest and importance by any department of geological investigation.

THE LOWEST FORMS OF LIFE.

PART II.

THE PROTOZOA OR LOWEST ANIMALS.—"VORTICELLA," OR THE "BELL-FLOWER ANIMALCULE."—CONCLUSION.

BY THE EDITOR.

THE reader will recollect that we were last occupied in investigating the nature of that simple fabric, known as a vegetable cell, and that beautiful plant-form, called *Volvox globator* ("the rolling globe"), which is a group or assemblage of such cells endowed with the power of locomotion.

If he feels disposed once more to join our little family circle, he will have an opportunity of considering with us some objects of still greater beauty and interest. As we sat at the tea-table a few evenings subsequent to the one to which we referred in our last number, our conversation turned upon the subject of our former inquiries, and I was asked in what the difference between a plant cell and an animal cell consisted.

My reply was as follows :—

"For the most part we find the animal cell enclosed, in the same manner as the vegetable cell, in a capsule, or 'integument,' as it is called; the latter word expressing the same meaning as a 'skin' in the higher animals. Both in its constituent compounds and in its anatomy, however, the animal differs from the plant cell: the latter I have already described; its 'cell-wall' is a distinct membrane, consisting of a substance called 'cellulose,' which resembles starch in its nature; and within that, we find the *cell contents* ('endochrome'), believed to be surrounded by an invisible membrane of an albuminous character; the cell-contents consist, as you know, of those green granules that are formed within the capsule, and which float about in the more fluid sap. Now the *animal* cell has no such external coat of cellulose, as we find in plants, but only the inner albuminous envelope, which in the animal cell is the outer protecting coat, or skin, and consequently we find it to be much firmer and thicker than in the plant; in fact, you might say that in the animal cell, the inner membrane being of a tougher consistency than in the plant, the outer one is usually dispensed with. In its place, however, we often find what is called by microscopists, a 'carapace'—a comparatively hard shell, or armour, of which the true nature is not yet clearly defined.

"Then again, in the animal cell the internal granules are not

formed as in the plant cell, but a regular consumption and digestion of food takes place, even in such as do not exceed one-thousandth part of an inch in diameter. . . . . Ah! you may smile; but I mean to feed some of them this evening, just as they feed the higher animals at the Zoological Gardens; and when you have seen them at meals, perhaps your scepticism will be at an end."

At this last observation of mine, my little auditory laughed outright, for they regarded the statement that an invisible globule, "not exceeding one-thousandth part of an inch in diameter," could be fed in the same manner as a quadruped, as a barefaced attempt to practise upon their credulity; and, laughing heartily, we all adjourned to the study to witness this wonderful phenomenon.

"This is a very graceful cluster of flowers," my pupil remarked, as she leaned over the microscope, after I had prepared a slide for her inspection; "but you said that you were going to exhibit to us some forms of animals."

"Why, good heavens! these plants are all instinct with life! How they sway from side to side, coiling and uncoiling their stems!—and see, that central one that towers above the rest has disappeared, whilst I speak. No! here it is again, slowly uncoiling its footstalk.

"How beautiful! There to the right are two, drooping gracefully, with all the elegance of Canterbury-bells, and wooing one another like lovers; and yonder to the left we have matrimony typified—two bells upon one stalk.

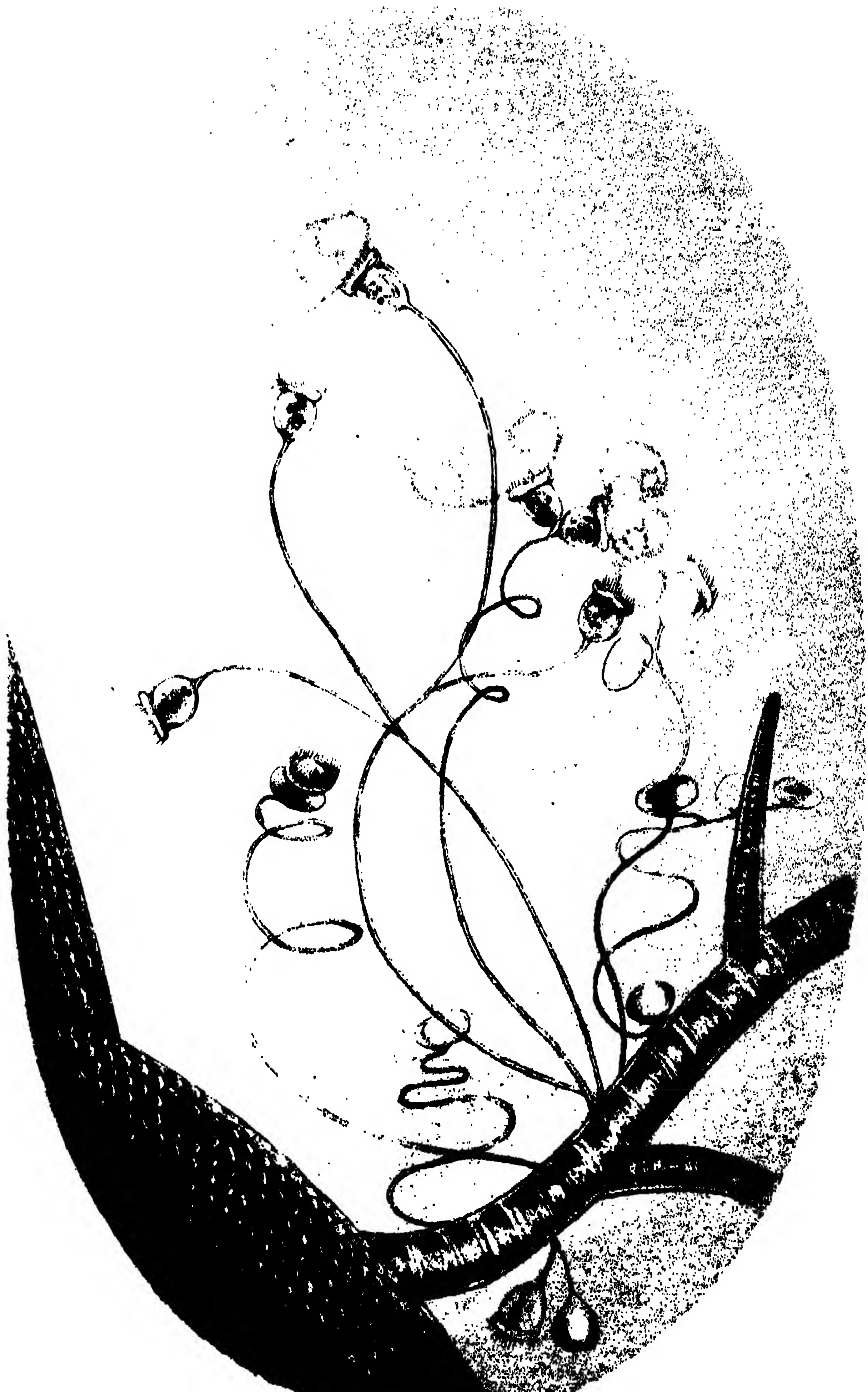
"And look! even the cups of the flowers have the power to change their shape; now they are globular, now vase-shaped!

"How lovely! *This* scene, indeed, eclipses your Volvox and all your plants—that is to say, if these be not plants also, for your disclosures have rendered it impossible to judge of the true nature of these invisible forms by any ordinary standard. I could sit and gaze on them for hours and watch their varied movements.

"But what are those blue flakes that revolve in a current around the cups of the flowers?

"Well, I confess you are unfolding to us the invisible works of nature, with ever-increasing interest and attraction. Let them all approach and witness this wonderful sight, and then we will again be patient listeners and learners."

"You will *have* to be a patient listener this evening," I remarked; "but as you will only be doing penance for the ridicule with which you just now treated the information that I gave you, I shall not deem it necessary to apologize for testing your powers of endurance.



"I intend, this evening, to answer fully some questions that you put to me the last time we examined these forms together; but first I will satisfy your curiosity, by saying that the 'flowers,' which you have just been inspecting are living creatures called *Vorticellæ*, from the curious little vortex or whirlpool that they create in the water in order to attract their nourishment, consisting in this instance of the flakes or particles of indigo, with which I have been feeding them. Now, where is your unbelief?"

"Well, I confess that my incredulity got the better of my judgment; so pray pardon me, and proceed."

"In investigating these mysterious living atoms, I must, in the first place, say a few words to you concerning those two curious forms of life, the *lowest* of any yet discovered, *Amœba* ('the changing animalcule'), and *Actinophrys Sol* ('the rayed or radiating Sun'), both of which we inspected on a recent occasion. The first of these, Amœba, puts out temporary members ('pseudopodia,' or false feet, as they are called), and by this means moves about in search of food, or rather, I should say, until it accidentally comes into contact with something that will serve for its nutriment. The mode in which these feet are *improvised* is very curious. Amœba itself consists, practically speaking, of a mass of cell-contents (called by naturalists 'sarcode'), without a cell-wall, but there is probably at its circumference a thin elastic membrane, which becomes extended in the direction in which the animalcule means to move. At first the false foot is transparent, but presently the granules that float about in its body set up a current in the direction of the false member, and, flowing into it, cause it to resemble the rest of the body. (Plate vii., fig. 1.)

"When the Amœba comes into contact with any substance suitable for its nourishment, it enfolds it with these false members, and drawing it into its body through an extemporised aperture, it sucks out the nutritious constituents by the digestive process, and ejects the indigestible particles by another opening in the body ruptured for the occasion. And, wonderful to relate, it performs this operation, so indispensable to the maintenance of its lowly existence, without any organs of digestion whatever. The only approach to organization, visible within its body, is a little hollow sphere, that appears to serve as a receptacle for the fluid product of the digestive process—the blood, as it may be popularly called. This sphere contracts and totally disappears from time to time (hence it is called the 'contractile vesicle,') and then gradually dilates again; and, as microscopists believe it to be a kind of circulating apparatus, analogous to the heart, they have called

this rhythmical contraction and dilatation, the 'systole' and 'diastole,' terms employed in connection with the movements of the last-named organ in the higher animals.

"Thus you will see that Amœba which is at present regarded as the lowest type of animals, is in fact a mass of cell-contents, or 'sarcode,' without a definite cell-wall, possessing the power of locomotion, and the capability of nourishing itself. How it reproduces itself; and whether it really is a perfectly formed animalcule, or only the early stage of one, is not definitely ascertained.

"The other living type, Actinophrys (pl. viii., fig. 2), differs from Amœba chiefly in its members of locomotion being constant, and in the structure of the body being reticulated after the manner of a honeycomb, and not gelatinous; indeed, it resembles the section of a minute twig of the pine.

"Its locomotive members (pseudopodia) are believed to have the power to paralyze its prey, which you will be surprised to hear often consists of highly organized animalcules.* These it engulfs in the same manner as Amœba, digesting the nutritive portion, and ejecting what is indigestible.

"Let me just relate one more circumstance concerning Actinophrys, and then we must pass on to the bell-flower animalcule.

"When two of these forms come into contact with one another it is not at all uncommon for them to coalesce so completely as to form one perfect animalcule; and the new creature possesses precisely the same properties as the two of which it is composed.

"I mention this circumstance, in order to show you how remarkably simple must be the structure of the 'lowest forms of life,' when two of them can amalgamate, and yet retain their vital properties unimpaired.

"In concluding my remarks concerning them, I would observe that they have been placed by systematic zoologists in a group of animalcules, called 'Rhizopoda,' or 'root-footed,' from the peculiar shape of their members of locomotion.†

* Amœba, I believe, feeds on the simplest kinds of plants.

(Pl. viii., fig. 2, represents *Actinophrys Sol*, as I have myself seen it, seizing and digesting a Stentor, or trumpet animalcule.) In Actinophrys the contractile vesicle is clearly visible, and after a meal its contractions and dilatations are very regular and perceptible. (Fig. 2*a*.)

† Mr. J. R. Greene (whose excellent little work, "A Manual of the Sub-Kingdom Protozoa," is strongly recommended to the *student* of this branch of natural history) aptly describes Amœba; and the extraordinary phenomena which accompany the life of this lowliest of living forms warrant me in making an extract—even at the risk of a little repetition :—

"When first placed under the microscope, the Amœba presents the appearance of a globular mass of a semi-transparent jelly, destitute of any apparent organization. This seemingly helpless being soon, however, commences to show signs of life, by pushing out in various directions portions of the jelly-like substance of which it is composed. By expanding one of these prolongations,

"The bell-flower animalcule, or Vorticella, as it is called by microscopists, belongs to a group of animalcules, termed 'Infusoria,' in consequence of their being sometimes found in infusions of decaying animal and vegetable substances.

"To the investigation of this group of animals, Ehrenberg, an eminent Prussian microscopist, has devoted a considerable portion of his lifetime, and although his observations upon their *structure* have been shown to be incorrect, yet it is to him that we owe our knowledge of the existence of vast numbers of these forms of life. I shall not perplex you by recording the errors into which Ehrenberg has fallen, but will now endeavour to communicate to you, as popularly as possible, the authentic details that I have been able to collect by reading and observation, concerning the natural history of the bell-flower animalcule.

"Whilst I am describing its movements and habits, however, it would be as well for you to have one of the living animalcules under your eye, and I will therefore try to find one for your inspection.*

"Vorticella consists, as you perceive, of two parts, of which the one may be familiarly called the cup, and the other the foot-stalk, or as they are termed by naturalists the 'calyx' and 'pedicle,' and certainly of all living forms none so closely resembles a flower in shape as does this one.

"The calyx is formed after the model of a cup, or vase, but it has a contractile power (as has also the pedicle), and frequently it assumes a globular form.

"The pedicle is a long contractile appendage to the cup, and it derives its power of coiling and uncoiling itself from the delicate filament, which you may trace through its whole length." (Pl. viii., fig. 3*a*.)

and then drawing after it, or rather into it, the remainder of its body, Amœba slowly advances in a somewhat irregular manner. . . . Should the Amœba, in its progress through the water, come in contact with any foreign substance of small size, the latter is tenaciously grasped by the pseudopodia which coalesce around it, and thus the morsel soon becomes inclosed in the interior of the body.

"There is no true oral orifice (mouth), and the mode in which deglutition is performed by the Amœba may not inaptly be illustrated by forcing a stone into a lump of clay, or similar plastic material. The power of selection possessed by the Amœba would appear to be but slight, either as to the quantity or quality of its food. Inorganic particles, such as sand, are frequently ingested along with its more proper aliment. Sometimes the body of the Amœba appears as a mere transparent film, investing the substance swallowed; and it occasionally happens that it becomes impaled on the sharp point of some projecting object. The indigestible remains of the food are finally pushed out through some part of the gelatinous body."—(pp. 3-5.)

* The reader would do well to refer to plate vii., whilst following this description, unless he can obtain a living specimen. They are found in infusions of hay, also attached to duckweed in ponds, and in other localities.

"A kind of muscle, I suppose?"

"No, not exactly a muscle; it is a portion of the substance of the animalcule, endowed with this contractile property: that is the best definition that we can at present give of its nature. If you watch it *un*coiling (for it coils up so rapidly that the eye cannot follow the movement), you will distinctly see the internal filament elongate, and assume a wavy appearance as it is extended, until at length it becomes almost straight from end to end."

"But, stay a moment," observed my pupil; "how does happen that when the pedicle, as you call it, becomes extended, the cup, which, during the coiling process, had assumed the globular form, also expands, and there seems to be a kind of agitation all round the rim, when the flower is fully blown, if you will allow me to employ the expression? What is that vibration?"

"It arises from the action of an appliance that the animalcule possesses, to enable it to obtain a supply of nourishment,—a circlet or wreath of 'cilia,' little hair-like appendages, similar to those that I showed you upon the cells of Volvox."

"Why, then, this bell-animalcule may be a vegetable, after all, if it is furnished with such organs."

"On the same principle, then, you and I may be vegetables also the oysters that we consume. Have you forgotten what I told you concerning them, when I showed them to you upon Volvox: that they are found in ourselves, and are numerous in the gills of the oyster? In Vorticella, they supply the place of pseudopodia, the false feet of Amœba, and the Sun-animalcule; for, by their rapid vibrations, they cause a current to flow constantly in the direction of the mouth, and this brings with it a supply of nourishment for the animalcule. This I will demonstrate to you by an interesting experiment."

So saying, I removed the slide from the stage of the microscope, and, taking a clean one from my cabinet, transferred to it, from a small bottle, a fresh drop of water containing some more Vorticellæ.

"These animalculæ have not yet been fed with indigo," I observed, after having satisfied myself that the drop contained some of the living forms in question; and taking from a box of colours near at hand, a small cake of indigo, I rubbed it in a little water upon another slide, and then transferred a drop of the solution to the slide with water containing the Vorticellæ, and replaced it on the stage of the instrument, having previously covered it with a small piece of thin glass to prevent the evaporation of the fluid. This operation completed, I invited my friends to draw near, and inspect my little charges at their meals.

"So, these little flocculent particles that float about in the water are portions of the indigo in solution, are they?"

"Yes; they are the magnified flakes of that substance held suspended in the water; and now if you look at the rim of the calyx of one of the Vorticellæ, you will find that the current brings a continuous supply of the indigo into the mouth or oral aperture, as it is termed, of the Vorticellæ."

"So it does," said my young pupil, after watching the operation for a time; "and inside of the cup little blue balls or globules are formed,—portions of the food undergoing digestion, I suppose?"

"See how acute your faculties are becoming by observation," I exclaimed. "The globules are, indeed, portions of the food undergoing digestion, and I will describe this process, so far as we are acquainted with it, in Vorticella and other infusorial animalculæ.

"The body or calyx of the animalcule is composed of a little mass of substance similar to that of Amœba, but Vorticella is inclosed in an elastic contractile skin or integument. Some observers believe this 'skin' to be made up of two distinct membranes, the inner one being contractile, and *extending into the pedicle or foot-stalk, so as to constitute that remarkable contractile filament, which imparts the power of coiling and uncoiling to the appendage in question.* (Plate viii., fig. 3 *b.*) The soft semi-fluid substance of the calyx contains a rudimentary, digestive, and circulating apparatus, the food being admitted through an aperture situated within the rim of the cup. . . . . . I have been trying to call to memory some familiar object that will afford you an idea of the calyx or cup of Vorticella, but the only one to which I can compare it is a common breakfast cup into which a circular piece of cardboard has been inserted, so as to leave only the rim of the cup visible. Suppose you were to cut a piece of paper or cardboard to the shape of the cup at its widest part, and make a hole in the cardboard a little to one side from the centre, you would imitate to some extent the 'disk,' as it is called, which closes the wide aperture of the calyx of Vorticella. The circlet of cilia is disposed spirally upon the disk within the lip or rim, and is continued a little way into the mouth or oral aperture, which is represented in my simile by the hole in the cardboard that closes the aperture of the cup (fig. 3).

"Now, watch the current of indigo carefully, and you will perceive that it forms a kind of *vortex*, or whirlpool (hence the name *Vorticella*), the object of which is, that any particles of matter unsuitable for nutriment may be rejected; and, according to the observations of some microscopists, there is

an appliance within the entrance to the rudimentary stomach that aids in the selection of suitable nourishment."

"I see the little whirlpool very distinctly, for here the course of the current is plainly indicated by the innumerable particles of blue colouring matter mixed with the water (plate vii.); but, curiously enough, although I fancy I can see a little ball of food (of indigo, I should say,) forming near the mouth, yet I do not see the particles enter at the aperture." (Plate viii., fig. 3 *c*.)

"No; because they chase one another with such rapidity that it requires a practised eye to follow them in their course. You were correct in saying that you see a ball of food forming near the mouth. The food accumulates at the bottom of a little tubular or funnel-shaped excavation in the external envelope of the body (communicating with the water through the oral aperture), and when the ball has attained a certain size, it is forced, either by its own weight or by the current from without, into the interior substance of the calyx, whilst the formation of another little pellet at once commences. If you were to watch these pellets, you would find that, after they have escaped into the cup, they continue to rotate (very slowly in Vorticella, but more rapidly in some others of the Infusoria,*) until the whole of the nutritive portion is extracted, and then the residue is ejected at the rim, and carried away by the receding current. Some microscopists believe that it is expelled by a second special aperture. This observation may be correct, but I will not be responsible for its accuracy. So much for the digestion of the food. Now a word regarding the means whereby the liquid product of digestion is circulated through the body so as to minister to its growth.

"This fluid, which is analogous to the blood of the higher animals, is collected in a contractile cavity resembling those which we found in *Amœba* and *Actinophrys Sol*, but in the Infusoria it is more perfectly organized. You know in what manner our heart operates, driving the blood by its contractions through arteries to all parts of the body, and receiving it back through the veins. Well, in some of the Infusoria the contractile vesicle, which is, in fact, the first trace of a heart in the animal kingdom,† mimics this operation of the more

* Plate viii., fig. 4, represents the digestive process in another infusorial animalcule, "*Glaucoma scintillans*," in which it may more readily be followed:—

a Oral aperture, or mouth.
b Pellet forming at the bottom of the rudimentary throat.
c Pellets in the body.
d Digested remains of food escaping from the body.

† According to some naturalists, it is the rudiment of what is termed the "vascular water system" in the worms.

perfect organ; so much so, that the contractions and dilatations in both cases are known to physiologists by the same scientific designations, the 'systole' and the 'diastole.' In another of the Infusoria I have seen this action very perfectly displayed. The animalcule is called *Glaucoma scintillans* (the 'scintillating or sparkling Glaucoma'); and here, when the vesicle contracts, five secondary ones make their appearance around it, and into these spaces the fluid penetrates. As the central vesicle dilates again, its satellites contract and disappear." (Pl. viii., fig. *c*.)

"And are there any veins or arteries in the Infusoria?"

"I have not observed anything analogous to these vessels in the animalcule just named; but in another (*Paramecium caudatum*, pl. viii., fig. 5), I have noticed a number of little channels radiating from the contractile space.* These seem to represent the arteries; and when the vesicle contracts, they expand and become visible. Near the vesicle they are bulb-shaped, and they become smaller as they recede from the 'heart.' Just as in the case of the smaller vesicles that surround the central one in Glaucoma, these arterial vessels disappear as the contractile vesicle expands and receives back its contents. Is it not wonderful how the designs and operations of the Infinitely Great may be traced even in His infinitely small creations!

"And now, having explained to you the digestive and circulating process in Vorticella, and some of the other infusorial animalculæ, I must conclude its history by describing its mode, or rather, I should say, its modes, of reproduction. It is reproduced by at least three, and, according to some physiologists, by four, different methods. The first is by subdivision: that is the most simple and the most easily watched; indeed here is one undergoing subdivision: you had better all inspect it before I explain the process (pl. vii.). You will notice that there are two calyxes or cups upon one stalk."

"Yes; and one of the cups has a double circlet of cilia, one at the rim and another close to the stalk. What is the use of the second circlet?"

"I will tell you presently.

"When a Vorticella is about to subdivide, it becomes indented longitudinally; that is, from the stalk to the rim. This indentation becomes deeper and deeper until the calyx is separated into two parts, as you see, both remaining on the same stalk (pl. vii.). Presently the second circlet of cilia is formed on one of the cups (I say presently, for the whole process of subdivision rarely occupies above an hour), and these new cilia, by their rapid vibrations, twist the cup off the stalk.

* P. caudatum has two such spaces.

"The free Vorticella, that is, the calyx which has been detached, swims about very rapidly by means of its two circlets of cilia; but at length one of these disappears, namely, the circlet that was originally situated at the rim. This end of the calyx then attaches itself to some floating object, and puts forth a pedicle or footstalk, the opposite end becoming the one at which food is received, for a new 'mouth' is formed within the wreath of cilia that aided to twist it off the old footstalk. So you see the parts of the calyx change their functions, and very soon the process of subdivision commences afresh.

"Sometimes, however, the fission is not confined to the calyx, but extends into the pedicle; and under these circumstances, it is incomplete, and the two animalcules, or rather the two cups, remain permanently attached. When this abnormal process is often repeated, the whole group assumes an arborescent appearance, and such a group has obtained the name of Carchesium, or the Tree-Vorticella (pl. viii., fig. 6).* The group of living flowers, therefore (in some cases attached by their several footstalks to one central stem), is the result of *one* of the reproductive processes in Vorticella, namely, that of fission or subdivision.

"The next is called 'gemmation' or 'budding;' but it is not of such frequent occurrence. . . . . . . Let me endeavour to illustrate this budding process by a simile. Can you imagine a Canterbury-bell producing another cup through the growth of a bud, not upon the footstalk, but close to it, on the flower itself? If so, you will understand how the young Vorticella-bud grows, as it were, from the calyx of the parent (pl. viii., fig. 3). It is nourished by a connection with the latter until old enough to lead an independent existence, and then a circlet of cilia is developed at the part attached to the parent, by which means, as in the former case, it frees itself, swims about with the aid of its cilia, develops a pedicle, and becomes sedentary, or 'sessile,' as it is scientifically called."

"Just as in our case," said my pupil, laughing; "first it leaves its parents to sow its wild oats, and then settles down to a quiet life."

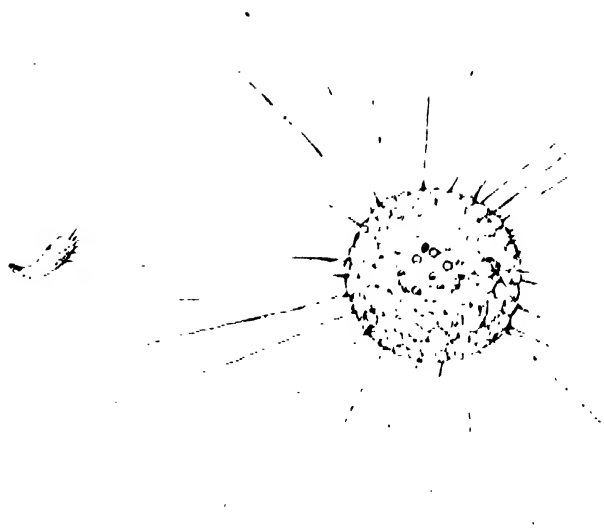
"Precisely so: and now for the last process of multiplication, which is rather more difficult to describe in popular language than the others, but I will do my best to explain it.

"Within the cup of the Vorticella there is a little sausage-shaped object called the 'nucleus.' (Pl. viii., fig. *d.*) At a certain stage of its humble existence the animalcule shrinks up into a ball, and a gelatinous or glutinous substance exudes from its body, entirely encasing it. In this state it is called

* From Dujardin's "Zoophytes Infusoires."

Fig. 1

Fig. 2



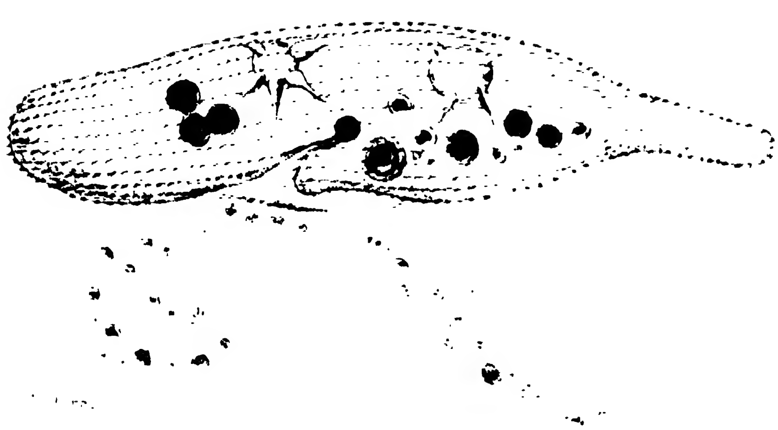
a

Fig. 3

Fig. 6.

Fig. 4

Fig. 5.



W. West imp.

'encased,' or '*encysted*,' that is, enclosed in a '*cyst*' (from a Greek word, signifying a bag). The cilia disappear, the pedicle soon drops off, the contents of the calyx lose their granular appearance, and the only signs of organization that remain are the 'contractile vesicle' and the sausage-shaped 'nucleus.'

"The last-named begins to subdivide in a similar manner to the contents of the cell in Volvox, and in the course of time the whole 'cyst' or capsule is filled with a swarm of little oval animalcules.

"At length, the outer integument can no longer resist the pressure of the young brood, and it bursts. The freed Vorticellæ make their escape and swim off in every direction, being furnished at their birth with a little wreath of long cilia. Just as in the two preceding cases, they sport about for a time in the watery element, and when they have attained a certain growth, put forth a footstalk, and 'settle down to a quiet life,' as you were pleased to designate their 'sessile' stage.

"I must now draw your attention to another parallel between these lowest forms of animal existence, and the *protophyta*, or lowest plants, namely, the 'settling down' and becoming encysted; for, if you recollect, precisely the same process preceded the reproductive act in the little ciliated plant forms, and not that alone, but the budding process, the 'gemmation' of Vorticella strongly resembles the same operation in plants, with this difference, not to be overlooked, namely, that the Vorticella bud derives its nutriment from the fluids in the parent, elaborated on the digestion of organized substances, whilst in the case of plants the 'pabulum' or food is derived from the inorganic constituents of the surrounding elements.

"More I cannot tell you about Vorticella, for it would occupy too much time to describe the various shapes under which it presents itself. Sometimes it resembles a shrub, of which the central stem only is rigid, and the branches with their calyxes contractile: it is then called 'Epystilis,' the 'pillar animalcule;' at others it is enclosed in a beautiful cup-shaped sheath; indeed, its varieties or species are manifold, but all are alike interesting and beautiful.

"Before, however, we bid adieu to these humblest forms of life, let me just remark that you are daily in the habit of employing, perhaps unconsciously, substances whose nature is akin either to the lowest animal or vegetable types.

"The common sponge, for example, which you use in your bath, is closely allied to Amœba; for whilst it was growing in the sea it formed the support or framework of an extended slimy skin similar to Amœba in its living properties. Sometimes the inner skeleton, instead of being flexible and horny, is silicious; that is to say, it is composed of innumerable flinty

particles, resembling radiating spikes, visible only with the aid of the microscope. Although a beautiful microscopic object, it is in that case valueless as an article of commerce.

"Some of the building materials employed by man are composed of the calcareous shells which formerly sheltered microscopical forms of a similar character; and the pyramids of Egypt are constructed of a stone that consists almost entirely of the shells of one well-known fossil species.

"Again, you have probably heard that the inhabitants of some of the poorer districts in Norway mix earth with their bread. This they call 'bergmehl,' or mountain flour; and Ehrenberg found, on examining it under the microscope, that it is composed almost solely of the exquisitely carved fossil cases or coverings of a number of very lowly forms, so lowly indeed, that it is undecided whether they belonged to the animal or vegetable kingdom. It is, however, usually supposed that they still retain sufficient organic matter to impart to them a slightly nutritive property; and they are so beautifully framed, notwithstanding their excessive littleness, that no collector regards his cabinet complete without specimens of the various types.

"And one more example you will find in a very fine polishing powder, which is employed on account of its hardness to burnish metals and stones, and in the flinty stone called 'tripoli,' from which it is obtained. This, too, consists entirely of fossil silicious shells.

"Many are the objects to which I could draw your attention, whereof you do not know the true nature, but which are constituted of these animated atoms, either recent or fossil; and naturalists have but just commenced the study of this branch of science, new substances being continually discovered in which these humblest of animated types are revealed with the aid of the microscope; indeed, it has been shown, beyond a doubt, that whole mountain ranges on land, and beds of sand in the ocean, are composed entirely of their invisible habitations."

It was late in the evening when I had concluded this brief discourse upon the lowest forms of animal existence; and, left alone in my study, I sat down, as is my wont, after inspecting the beautiful scenes of the microscopical world, to reflect upon the lessons which they convey to the thinking mind.

My thoughts wandered back to the time when all these strange phenomena, these evidences of the Creator's presence in every atom, were still concealed from the vulgar eye, and were known more imperfectly even than at present, and only to the privileged few. And then they sought to pene-

trate into the future; and I could picture to myself the time when every workman at his bench would be able to recognize in each fragment of the material that passes through his hands an evidence of the Wise Power which controls his own operations as well as those of nature.

And when I drew a comparison between the life of one of my own race and that of a Vorticella, I was surprised to find how many men there are who seem to take the animalcule for their model; whose birth, growth, nourishment, wanderings, and, finally, whose tranquil "fixed" existence all resemble that of the little bell-flower animalcule! A sense of awe crept over me when I recollected that, sooner or later, we all sink to rest as does the Vorticella, or the Volvox in its winter stage; but gloriously above all these thoughts rose the knowledge of the fact, that even these senseless, soulless beings do not *die*, but that the germ retains its existence and gives rise to fresh forms of grace and beauty.

"Fair summer's bloom and autumn's glow
    In vain pale winter brave;
  Nor youth, nor age, nor wisdom know
    A ransom from the grave!

"But morning dawns and spring revives,
    And genial hours return;
  So man's immortal soul survives,
    And scorns the smouldering urn!"

CONTRIBUTIONS TO THE HISTORY OF THE ROTIFERA, OR WHEEL ANIMALCULES.

BY PHILIP HENRY GOSSE, F.R.S.

II.

THE FLOSCULES

(Floscularia).

'TIS a lovely morning in the end of April. We have taken a long walk, and find ourselves in the midst of a bowery lane, with tall hedges overarching on either side—elm, and sloe, and hawthorn,—all glowing in the bright tender green, the fresh verdure of the opening spring. The road is hard and firm to the tread, for the nocturnal shower has only sufficed to lay the dust, and has been absorbed, while its myriad drops yet sparkle on the shooting grass-blades. Vegetation is marching with a giant's pace, after the dull sleep of frozen winter. The large glossy black-spotted leaves of the wake-robin are fringing the hedge-bank, and the swelling spathe is here and there seen, sending up its pointed canopy; but you must violently tear open the curtain if you would see the fair lady within, for she is not yet dressed to receive company. The beautiful heart-like leaves of the black bryony, vying with those of the arum in polish, and excelling them in shape, are rising on their slender twining stems, and rapidly creeping to the summit of the hedge. Even the very nettles look so fresh and tender that we half forget their insidious ferocity, and look with complacency on them as an essential element in the verdant scene.

But it is not *all* verdure: Flora smiles here too. Thick clusters of pale-yellow primroses sit in their crumple-leafed crowns, and scores of deeply-purpled violets are revealed by the gushes of fragrance that ascend from the tangled herbage. The white starry blossoms of the stitchwort spangle the bank, and among them the laughing blue eyes of the germander speedwell—"angels' eyes," as our country lads poetically call them—peep out by hundreds. Yonder, the tall erect spikes of the blue hyacinth are nodding, and the rose campion and ragged robin display their crimson flowers. Higher up, the sloes are white with bloom, and in the orchard over the hedge the delighted eye gazes on great masses of blushing silver.

The early butterflies are abroad. The garden whites, those

foes to our cabbages, are flitting everywhere. Yonder, we see the brilliant little copper playing, coy in its conscious beauty as a coquette in a ball-room; and here comes, sailing down the lane, the gay brimstone, paling the primroses on which it alights with its deeper hue.

Hark! from the apple-orchard is poured the mellow song of the blackbird. Soft and low, but most rich and clear, the notes are trilled. Presently he is answered by the loud rivalry of the missel-thrush, who vociferates, "You thief! you thief! you thief!" as loud as he can whistle: bad language, only redeemed by the mellifluous tones in which it is uttered. And there, overhead, in the brightening sky, is the soaring lark, pouring forth his gushes of sweet melody, which we have been hearing for the last half-hour, without adverting to it, busy as we were in indulging the eye, and only now suddenly awake, so to speak, to the full consciousness of the proximity of the cheery bird.

Here, beneath the arching fronds of the lady-fern and hart's-tongue, which, in this sheltered nook, the withering touch of frost has scarcely sullied, we catch glimpses of quiet water; a deep ditch, which has just sufficient fall to maintain a gentle flow, and to keep the water in purity. The aquatic vegetation is already greening the sides, and fast rising to the surface, destined, before long, to fill up the cavity with its grosser luxuriance, and then die away, for want of moisture, beneath the burning sun of June.

Now, this ditch is the terminus of our walk. Our sweet fresh stroll, through fields and lanes, in this early April morning, has had this identical rivulet in view as its object. So, after having drunk in the suffusing loveliness awhile, and gratified all the senses at once, sight, smell, hearing, and feeling too,—for the genial sun, just warm enough to be pleasant, and the gentle aura that fans the face, gratify that sense also,—we turn out half-a-dozen glass phials from coat-pockets, and, unfolding a twist of twine, lash one of them to the tip of our walking-stick, and commence operations. A little of the water is dipped up from the edge, and transferred to one of the spare bottles; then a second dip from near the bottom, keeping the dipping-phial inverted till the bottom is reached; then a third, from the middle of the weeds, and so on; and when we have made our collections we sit down on this felled tree, and examine.

A pocket-lens of two glasses, giving, when combined, a magnifying power of some twenty-five or thirty diameters, we bring to bear on each bottle in succession, holding it up to the light, and passing the finger up and down behind it to give a dark back-ground. What have we secured? Some trans-

parent worm-like larvæ of flies, a blood-worm or two (also fly larvæ, these); half-a-dozen pupæ of gnats alternately floating to the surface and vigorously scuttling down again; some water-fleas, minute leech-worms (*Planaria*), and young pond-snails; these chiefly in the phial of bottom sediments. Such are our captures, all capable of affording both amusement and instruction, but not the things we came for. We are out on the quest for ROTIFERA, and of these the water reveals but few. Gnat-grubs and water-fleas are particularly inimical to the elegant little denizens of the pools that we are studying, and where the former abound the latter will generally prove to be sufficiently scarce.

But *nil desperandum!* There is hope yet in the submerged vegetation; and so, stooping down by the ditch-brink, we drag up a mass of the water-crowfoot, the leaves of which, when growing beneath the surface, are cut into deep and slender finger-like filaments, while those which lie on the top are comparatively entire. A few of the lowest leaves,—the most ragged-looking, half-decayed, half covered with soft sediment,—are quickly plucked off, and pushed into one of the phials of water, and with these we go home in hope.

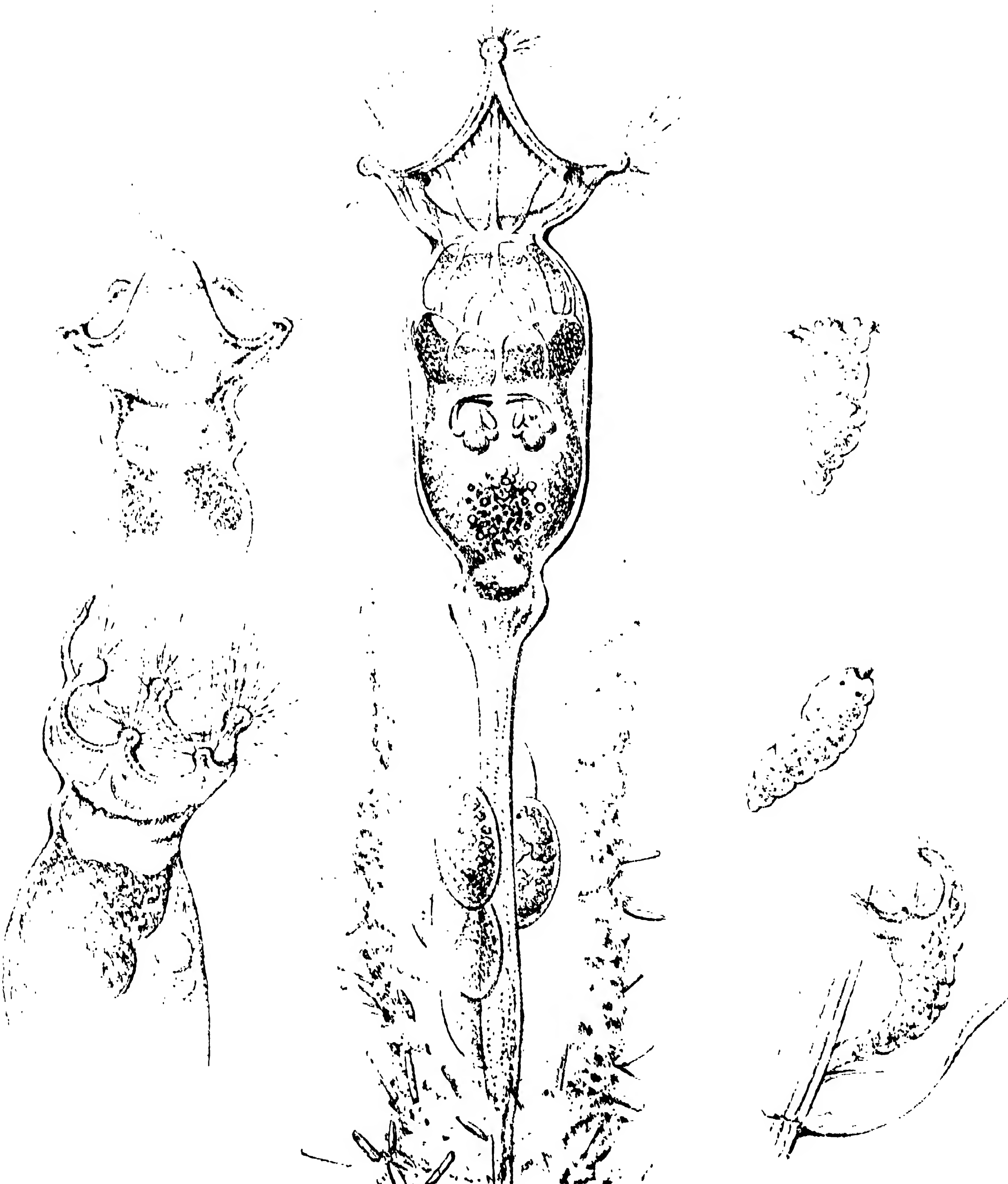
Seated before the microscope, one of these ragged filamentous leaves is cut off, and laid on the glass bottom of our live-box, a drop of water is put on it, and the glass cover pressed down. Now the filaments are examined in detail, with a low power, and presently we discover seated on them, as we had hoped, specimens of the lovely *Floscularia ornata,* which must now be described. (See plate x., fig. 1.)

With sufficient general resemblance to the Crown animalcule to warrant our uniting these two in one family, the Floscule differs from it in the following generic characters:—

GENUS FLOSCULARIA (OKEN).

Frontal lobes short, broad, knobbed, expanded; ciliary setæ very long, radiating, crowded about the knobs; jaws each of two teeth.

This genus, especially in its most common and best known species, *F. ornata,* is one of exquisite delicacy. It is far inferior in size to the *Stephanoceros,* and cannot compete with it in majesty of form, but it, perhaps, surpasses that fine species in elegance and grace. It may be compared to a long tubular flower, with a five-angled petal, somewhat like that of a convolvulus, the tube swollen, and contracted below the lip, and seated on the end of a long stalk. A glance at the figure in plate x. will, however, give a more exact idea of the graceful animal than this comparison, which yet has sufficient *vraisemblance* to have obtained for it more than one scientific



appellation;—Pallas having given to the species the name of *hyacinthinus*, under which name (*Vorticella hyacinthina*) it takes its place in Gmelin's edition of Linnæus's *Systema Naturæ;* and Oken making in 1815 a genus of it by its now accepted title of *Floscularia*, from *flosculus*, a little flower. The name of *ornata* was given in 1830 by Ehrenberg, who apologizes for not using Pallas's appellation, on the ground that the vagueness of the early microscopic observations make it somewhat uncertain whether their species was truly identical with this. Still, from the commonness of our little beauty, not much doubt can be entertained that it was this species which they saw.

The dimensions of the Beautiful Floscule, as measured by myself from an average specimen, are as follows:—The height of the case $\frac{1}{90}$th of an inch; height of foot $\frac{1}{100}$th; of foot and body to tip of tallest petal, $\frac{1}{60}$th; of entire animal from base of tube to tip of longest bristles, so far as they can be traced, about $\frac{1}{35}$th. Individuals, however, much exceed these dimensions: I have measured one which attained the height of $\frac{1}{30}$th of an inch to the petal-tips, which may have given $\frac{1}{25}$th as the total altitude: the case of this specimen measured $\frac{1}{40}$th of an inch.

The foot is a slender column, not perfectly straight, nor of uniform thickness; it often displays irregular bendings, sometimes amounting to abrupt knee-like angles, and has in general one or more swellings or bulgings, equally irregular. These are accidental, for they do not always occur at the same point: there is, however, one which is more constant, though not uniformly so,—a considerable angular swelling just below the merging of the foot into the body.

The body is sub-oval, sometimes very regularly, but at other times (plate ix., fig. 1), a little enlarging at the upper end. Above this, there is a constriction or neck, but not so well defined a collar as in *Stephanoceros*. From this neck the beautiful flower-like disk opens, an expanse of the most exquisitely delicate and brilliantly transparent membrane, which, as I have said, forms five blunt points,* equidistant, and

* I have never been able to obtain a specimen with more than five points. Ehrenberg, however, assigns six to it, in his specific diagnosis of the species, and in his description. He figures one, however, with five. Dujardin and Peltier in France, and Leydig in Würtzburg, allow of no more than five. On the other hand, Dr. Dobie quotes Mr. Hallett, who "finds *F. ornata* six-lobed." Mr. Slack seems to cut the knot by attributing to the animal a power of changing the number at pleasure. His words are remarkable:—"Although it is easy enough to count them in *some* positions, the observer may have to exercise a good deal of patience before he is certain whether they are five or six. *For a long evening only five could be discerned in the specimen now described, but on the next night six were apparent without difficulty or doubt*" ("Marvels of Pond Life," p. 81). This is sufficiently precise, and Mr. Slack is an excellent and careful observer; yet surely the power of altering the outline of the front, implied, cannot be admitted without reluctance by one who is acquainted with the animal.

somewhat rising, so as to give a trumpet-like contour to the outline.

One of the angular projections of the disk is considerably higher than the rest, and this is the dorsal one; so that the plane of the five knobs is not horizontal, but oblique, facing forwards.

A very remarkable feature in the animal, and one to which it owes much of its peculiar elegance, is that each knob is beset with straight bristles, of exceeding slenderness, and of great length, which are not set in one plane, but radiate in every direction. Ehrenberg says, there are from five to eight on each angle, but probably the poverty of his instrument deceived him. I have counted from forty to fifty on one knob. When the animal contracts, all the bristles are drawn parallel into a single pencil, and concealed within the body; and this arrangement is well seen as they slowly protrude, in the act of eversion. They are motionless when expanded, but while protruding, and in the instant of expanding (falling, as Mr. Slack well says, on all sides in a graceful shower), the pencil is seen to be agitated with a close and rapid thrill or wave, which runs along it, and looks much like the flickering of a candle-flame. It ceases the instant the disk is expanded.

The Case.—Like the *Stephanoceros*, the *Floscularia* is a householder, dwelling in a tenement of her own construction, which, if not very strong and stable, at least serves her turn. It is a gelatinous tube of considerably greater diameter than the animal's body, attached by its base to the stem or leaf of some water-plant, and standing erect with an open mouth. Its outline is even, that is, not thrown into those strong transverse folds which that of the Crown-wheel displays,* and in itself is so evanescent that it can only be discerned with difficulty as the slightest possible film, when clean. When old, however, it takes a dull yellowish hue, and becomes conspicuous, from the multitudes of minute *Navicules*, *Monads*, *Microglens*, and other organisms, and atoms of floccose sediment that are attached to, and imbedded in, the evidently viscid surface. The upper edge or brim can rarely be detected at all: in instances in which I have seen it, it was irregular and ragged, and so flexible that when the animal suddenly and forcibly contracted, the margin was drawn in after it, inverted for a short distance by the force of the vortex. It was evident that its substance was thin, inclosing a free cavity, and not solid up to the skin of the animal, as in *Stephanoceros*. A curious contretemps once showed me this. A little *Pleurotrocha*, a vagrant wheel-animalcule of another kind, roving about in the inquisitive manner common to its family, visited an expanded *Floscularia*,

* In one example, I have seen the case of *Floscularia ornata* lying in a multitude of minute and close-set transverse wrinkles.

and actually intruded into its disk; yet it was not till after several seconds that the Floscule, perhaps taken aback at the insult and deprived for the moment of its presence of mind, contracted itself. Presently it did, however, and that vigorously, when the rush of inflowing water carried the unprepared *Pleurotrocha* before it, quite into the tube. Here it began to make efforts to regain liberty; yet not, as might have seemed obvious, by the way it had entered, but through the side of the case. His pushings showed that this was thin, soft, and flexible, though sufficiently tough to resist his efforts, till at last he found his way out by the regular road.

The case is doubtless, as with *Stephanoceros*, an excretion thrown off from the skin, and moulded to its cylindrical form by the movements of the body on the foot-base, as a pivot.

THE NUTRITIVE SYSTEM.—The long bristles do not appear to have any power of forming currents in the water, not even in that subordinate degree which we have seen exercised by the *Stephanoceros*, in maintaining a sort of vortical prison, in which the victims are kept in ward. Yet there is a distinct vortex in the disk of the Floscule, and minute organisms are drawn into it from a considerable distance, and whirled round and round till they are swallowed. On the admixture of carmine or indigo with the water in the live-box, there is seen within the concavity of the disk a vortex, which takes an oval form, the longer diameter of which is perpendicular, and whose plane is from right to left of the animal.

The whole of the upper part of the body is lined with a very sensitive, contractile, partially-opaque membrane, which, a little below the disk, recedes from the walls of the body, and forms a *diaphragm* with a highly contractile and versatile central orifice. At some distance lower down another *diaphragm* occurs, and the ample chamber thus enclosed forms a kind of *crop*, or receptacle for the captured prey. Below the second *diaphragm* is another capacious chamber, which we must consider as a stomach, since digestion evidently commences in it, and it opens into the intestine.

The *mastax*, or bulb which ordinarily incloses the jaws,* is wholly wanting: the dental apparatus, which is very small, evidently springing from the common wall of the stomach, just below the second *diaphragm*. That this absence of the *mastax* is real, and not illusive, is proved by the facts that the *Infusoria* swallowed pass into the stomach, where they accumulate in its wide cavity; that the jaws are seen to act on one and another, according as they come within reach; and that after such action they pass off again into the same cavity, to undergo another

* See pp. 34 and 35, notes.

mastication, when chance again brings them within reach of the teeth.

From the ventral side of the ample *crop* that precedes the stomach, there springs, in *F. ornata*, a perpendicular membrane or veil, extending partly across the cavity.* This is free, except at the vertical edge, by which it is attached to the side of the chamber; and being ample, and of great delicacy, it continually floats and waves from side to side. At the bottom of this *veil*, but on the dorsal side, are placed the jaws, consisting of a pair of curved, unjointed, but free *mallei*, with a membranous process beneath each (fig. 1).

A large *Floscule*, eagerly feeding under my observation, presents the following phenomena:—In the water there are numbers of the green *Euglenæ* of different species, such as *E. rostrata* and *pyrum*, and of the beautiful *Chlorogonium*. These, roving near the expanded disk, are seen to be drawn into the funnel, though the long setæ remain perfectly motionless. After being hurled to and fro in the funnel awhile, the granular membrane closes suddenly upon them, and in the same instant the *Floscularia* contracts itself forcibly, extending again immediately.

The interior is now seen to be in active motion, no doubt masticating the *Euglenæ*, but the opacity does not permit the process to be distinctly discerned. In this specimen the upper half of the viscera was of a rich green, doubtless from feeding on these organisms; the lower viscera were deep red-brown.

While I held my watch in my hand five minutes, I watched just twenty animalcules engulphed, of various kinds, mostly small; these were accidental stragglers, scarcely any being visible at any one time in the field. It seems to be a successful preyer; an animalcule coming within half the body's length is sure to be involved, and once in, it rarely gets out.

THE CIRCULATION AND RESPIRATION.—No contractile bladder and no system of ciliated tags, such as I have described in the previous paper, have I ever been able to discover in this genus, nor has any other observer, so far as I am aware, except Dr. Leydig, who describes and figures a small bladder in *F. cornuta*.† I have, however, seen traces of a very remarkable vascular system, which I have some reason to think exists in *Stephanoceros* also, perhaps in connection with the tortuous threads, perhaps independent of them. This I will describe.

* Dr. Dobie considers this waving *veil*, in his *Floscularia cornuta*, to be a slit in the *diaphragm*, fringed with vibratile cilia, the motion of which, as he thinks, gives rise to the peculiar serpentine movement always observed at this point.—(Ann. Nat. Hist., 1849.)

† Sieb. and Köll. Zeitsch.; July, 1854. He assigns it, however, to the *ventral* side, which certainly is not where I should expect to find it, if present.

Dr. Dobie had observed,* in *Flosc. cornuta,* immediately below the integuments, groups and lines of very small granules continually in a state of rapid molecular motion, in appearance exactly resembling the molecules in the cusps of *Closterium.* Besides the molecular, they are subject to another motion, for occasionally they move from one part of the surface to another, in currents not very distinct nor persistent, and in no definite direction. He has seen these granules running in lines down the foot, and collecting in groups.

In both this species and in *F. ornata* there are to be seen well-defined clear bands permeating the disk in a symmetrical manner; and in a specimen of the latter I saw that these are very distinctly vessels, with walls, in which minute globular granules are suspended in a hyaline fluid. (See plate ix., fig. 1.) They have no proper circulatory motion, but the muscular movements of the animal change the position of the granules, and drive them to and fro, so that the form, direction, and dimensions of the canals can be easily perceived. Especially in the moment of expansion, after the contractions, which are almost every instant occurring in this sensitive creature, the granules are propelled with force up the canals, and in particular through the central vessel of the dorsal ray of the petaloid disk into the angle, where they accumulate, and thence through a circular vessel around the edge of the terminal knob. In this latter vessel a tremulous motion often remains among the granules after those in the other vessels have subsided to rest. The order of the vessels, so far as they can be discerned in the dorsal aspect, is as follows :—A rather wide vessel encircles the neck or constriction below the disk; thence perpendicular tubes, one in the centre of each petal and one intermediate, go off to join the marginal vessel of the disk, which follows the direction of the edge, and which sends off small circular vessels to the terminal knobs. From the lower side of the cervical vessel similar branches proceed downwards, and join a transverse but undulating vessel that appears to run along the line at which the granular and sensitive membrane relinquishes its contact with the internal skin of the body, and folds inwards to form the first diaphragm. Posterior branches are in turn given off from this, which interlace and anastomose in their course down the walls of the body, forming a loose network, with long meshes (much less distinct, however, than those of the anterior region), which unite at length into a single vessel that penetrates the slender elongated foot, even to its extremity, for I saw a single granule of the same kind as those of the anterior vessels close to the base of the foot, and a cluster of them a little below the junction of the body.

* "Annals Nat. Hist., Oct. 1849."

THE NERVOUS SYSTEM.—I have not been able to find any trace of a brain in any of the species of the genus. Two eyes are discernible in the new-born young, and even in the embryo some time before maturity. I have also, by using reflected light, detected these organs in half-grown individuals, which had well-formed and conspicuous cases. In an adult *F. cornuta* I have seen a single eye by reflected sunlight, and two in unhatched eggs, and in young that had developed the disk. The eye in the adult, *though now and then it shone out brightly, was frequently invisible* with any adjustment of forms :—so delicate and difficult are often these determinations! In another of the same species I was able to bring out under pressure one eye, minute, but perfectly distinct, *but only one.*

Around the neck (in *F. ornata* and *cornuta* certainly) goes a band of greyish granular substance, which sends off threads toward the margin of the disk, and in some specimens may be traced running as an evanescent thread around the edge, close to the marginal vessel. These may be, and probably are, threads of nervous matter.

THE MUSCULAR SYSTEM closely resembles that of *Stephanoceros*, but it is much less distinct. The action of muscular threads stretching across the clear disk to the knobs and intermediate points, whereby different parts of the outline are twitched inwards, and the whole more or less collapsed, can often be seen.

THE REPRODUCTIVE SYSTEM AND DEVELOPMENT.—The organs of reproduction, so far as known, agree with those already described. The ovary, a large translucent organ, nearly fills the ventral half of the body, and may generally be recognized either by its immature eggs,—clear spherules, each with its nucleus,—or by a great semi-opaque developing egg, as yet soft and shell-less, in the lower part. On being extruded, the eggs, now clothed with a hard and brittle shell, of a long-oval form, accumulate in the case, sometimes adhering to the foot and body of the animal, sometimes to the interior wall of the case (plate ix., fig. 1).

Several hours after being laid, the egg-shell bursts, and the infant *Floscule* makes its appearance. It is a white, cylindrical maggot, blunt at the front end, with a central orifice, whence protrudes a short brush of cilia; but the margins are capable of unfolding, when the cilia are seen to form a whorl around the truncate summit, swiftly rotating (fig. 2). The margin soon begins to bud forth the little knobs, around which the cilia are gathered; these quickly increase in length, and the angular flower-like disk gradually forms (fig. 3). Meanwhile, the little creature, which was at first free, attaches itself by its hinder end, and assumes the conditions as well as the form of the parent. The case, however,

is not discernible till adult age: though, doubtless, it begins to be excreted early.

As in the adult, the long bristles are perfectly motionless in general, but there are short cilia distinctly vibrating on the margin. The little animal in this stage frequently contracts itself: the jaws are plainly seen, and are often open and shut.

Nothing has yet been discovered of the male sex, if it differs, as is in all probability the case, from the female.

Ehrenberg described and figured a second species, which he named *F. proboscidea*, with the following remarkable character:—"Out of the centre of the six-parted, sometimes apparently five-parted, wheel-organ [disk] projects a great cylindrical, somewhat flexible tube, which seems to have a large opening in front. The anterior end of this snout-like tube, as well as the knobbed points of the wheel-organ, carries long inactive cilia [bristles], which rotate strongly only partially, when they bring food." This species has not been seen by any other observer, and there is some suspicion that it was the result of defective observation: yet as the eminent professor says he found many specimens, and on two occasions, we must not hastily reject it. It occurred on the leaves of the water-violet, in a ditch near Berlin.

In 1849, Dr. Dobie described two other species under the names of *F. campanulata* and *F. cornuta*. The "Micrographical Dictionary," indeed, speaks of these as "doubtfully distinct;" but without reason, for having repeatedly met with both, I can vouch for the accuracy of Dr. Dobie's descriptions and figures, and for the permanence of the species.

The former (see plate ix., fig. 4) differs from *F. ornata* in the great breadth of the disk, as compared with the body. It forms a wide, shallow funnel, the edge of which projects into five very obtuse points, without knobs, the dorsal one broader and higher than the rest, and frequently arched inwards. All the points are beset with the usual radiating bristles. The dorsal projection I have occasionally noticed to present an appearance of perforation, but it may have been illusive. A clear, round, well-defined space will sometimes form in the midst of its area (see fig. 4), of which not a trace can be discerned before or after. All round the edge of the disk there passes a narrow band of granular tissue, which seems to be a continuation of the sensitive contractile membrane which lines the upper part of the body, and forms the crop; for it may be traced along each side of the neck (in this species a distinct broad collar), to the margin of the crop. It has thickenings at the angles of the disk, and at the constrictions of the collar.

The ciliary vortex, as in *F. ornata,* brings in animalcules to the funnel-disk. If they are not carried far in, the margin

makes a slight and momentary contraction, by which the prey is forced downward; but more commonly the sensitive tissue that encircles the first neck contracts upon the prey, and keeps it from escaping, until the centre of the diaphragm can grasp it, which is but the work of a moment, when it passes into the crop with a quick, swallowing motion. This cavity commonly holds several animalcules; I have seen a little *Euplotes* (an infusorium of unwonted vigour and high organisation) engulphed, and crawling rapidly about by means of its hooked feet for some time, the jaws of the Floscule remaining still, as if despairing of dealing with it until its activity ceased, which it did after a while. Generally the prey introduced is immediately brought to the jaws, which then work upon it, pounding it as it were with the points of the teeth. For some time this seems to make no impression, but by and by we discern that the surface of the animalcule is indented, and that it is growing shapeless; it is then returned to the upper portion of the stomach, where digestion appears to go on, as this part of the viscus is of a rich green hue, derived doubtless from the juices of the coloured organisms. The lower or intestinal portion is of a brownish colour, and turbid.

I have not seen the eggs of this species; but half-grown young ones, in which the dorsal angle was very prominent and horn-like (see plate ix., fig. 5), I have found in the angles of the leaves of a water-moss. The full-grown animal is one of peculiar elegance.

The Horned, or Fingered Floscule (*F. cornuta*) of Dobie (see plate ix., fig. 6), has been elaborately described by Leydig (in 1854) as if new, under the name of *F. appendiculata.* I also met with it, and described it in MS. (in 1850), before I was aware of Dr. Dobie's Memoir. The substantial agreement of three descriptions, each independent of the others, satisfactorily establishes the species. It agrees, however, with *ornata* in all points, except that the dorsal projection of the disk is furnished with a slender, erect finger behind the knob. This is constant, even the young displaying it as soon as the disk is formed. It is seated on a fleshy pedestal projecting behind the dorsal lobe, just below the knob, which, as in *ornata,* is higher than the rest. The finger is not ciliated, nor does it appear to be separately moveable; it has always a wavy course. It may possibly represent the antenna.

The case, according to my experience, is exceedingly difficult to see, nor have I been able to discern the least definition of outline, but only a slight granulation, which is moved when the animal rapidly retracts itself. The eggs are laid to the number of seven before there is any appearance of life in the embryo. They usually hang around the long foot, rather low down; but

are attached, not to the foot, as in *ornata, but to the interior of the case,* which is thus seen to be very thin. The development of the young does not materially differ from what has been remarked in the other species, except that the wreath of infantile cilia is larger and longer.

EXPLANATION OF THE ILLUSTRATIONS.

Plate ix., fig. 1, represents an adult *Floscularia ornata,* viewed from behind, magnified two hundred diameters. Eggs in various stages of maturity are seen clustered around the foot, and one egg-shell, from which the young has escaped. Fig. 2 is a young one soon after birth; and fig. 3, one farther advanced.

Fig. 4 represents the disk and upper portion of an adult *F. campanulata,* viewed from behind; and fig. 5, the young half-grown, of the same.

Fig. 6 represents the disk and upper portion of an adult *F. cornuta,* viewed sidewise. All the figures are taken from the life.

REMARKS ON THE NATURAL HISTORY OF COTTON.

By Edwin Lankester, M.D., F.R.S.

THE interest that just now attaches to the question of the supply of the raw material for our great staple manufacture will perhaps be deemed a sufficient apology for a few remarks on cotton from a natural history point of view. The discussion of this subject may also draw attention to the advantages to be derived from the study of the natural history and relations of this important product to other natural productions, by those who cultivate and manufacture it. It must be obvious to every one, with regard to the raw materials of our great manufactures, that it is but prudent that we should not be dependent on one nation or one country for our supply, as political events or unfavourable seasons may cut off or shorten that supply, to the interruption of business, or the production of great national disasters. In such a condition, however, we are nearly placed in this country by our dependence on America for the chief article of our manufacturing industry. We can only expect to repair this error by an intelligent study of the nature of the plant which yields us cotton, and especially the conditions which are necessary for its successful cultivation in other parts of the world. It is not sufficient that we are anxious to grow cotton in other places, or secure it from other sources; before we embark our capital in such an enterprise, we must understand the nature of the soil and climate in which the cotton-plant of America is cultivated, and seek to introduce it in those countries which promise to fulfil all the requirements necessary for its successful production. The past history of our attempts at introducing the culture of our commercial products is full of interest and instruction. In our efforts to introduce the silkworm into India we have failed, because we have not studied the habits of the silkworm, having expected that the peculiar species of China and Europe would feed on the plants which afford nourishment to the wild species of India. The failure of the cultivation of silk in England has arisen from the neglect of observation that the mulberry of England was a different species from that on which the silkworm was fed on the Continent of Europe. The expenditure attendant upon the introduction of the Merino breed of sheep into England might have been spared, had the habits and climate in which that animal flourished been studied

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before extensive flocks were purchased and attempted to be reared in this country. These, and a hundred other facts, show how important is the study of the natural history of the materials which are employed in our national industry.

What is true of the production of the raw materials of our manufactures, is also true of the nature of the material; just in proportion as the workman is acquainted with the properties of his tools, and the materials on which he works, will he be enabled to improve his manufacture and increase the comforts of the community for which he labours. The great advances in our manufacturing industry, and the improvement of the articles manufactured, have not arisen so much from demand on the part of the public, as from the intelligent investigation of the properties of the raw materials of our manufactures, and their relations to the great physical forces of nature which man employs as his servants in the huge workshop of the world. It is, then, to the natural history of the cotton-plant and the properties of cotton that I wish more particularly to draw attention in this paper.

We have no knowledge of the precise time at which cotton began to be used by mankind; but there can be no doubt of its having been employed by the Hindoos earlier than any other race of men. The Jews were not at all, or only incidentally, acquainted with cotton. The cotton-plant grew wild in ancient Egypt, and may have been used occasionally for the manufacture of exceptional articles of general use or clothing; but the cloth in which they wrapped their mummies, and which they wore as clothing, was made from flax. We are told by Herodotus that the mummy-cloth of Egypt was made of the Byssus, and commentators down to the beginning of the present century regarded the Byssus as the production of the cotton-plant. It was left for Mr. Bauer, the distinguished natural-history artist and microscopic observer, at the suggestion of Mr. James Thomson, of Manchester, to discover that the mummy-cloth of Egypt was composed of linen, and not of cotton fibres. We are thus driven to the conclusion that Hindostan is not only the native country of the cotton-plant, but that it is the country in which its manufacture was invented and developed. Dr. Royle tells us, in his "History of the Use of Cotton in India," that its manufactured products, and even the process of starching it, are referred to in the Institutes of Menu, at as early a period as 800 years B.C. It is an interesting fact for us to know and dwell upon, at the present moment, that India is the true home of the cotton-plant, and the parent of its manufacture.

Without entering further upon the introduction of cotton fabrics and the cotton manufacture into Europe, let us inquire into the nature of the fibre that has thus found its way

from the banks of the Jumna and the Ganges to the valleys of Yorkshire and Lancashire, and become the source of a manufacture the largest and most important with which the world is acquainted. The weaving of fibres seems to have been a very early human art; the fig-leaves of our first parents must soon have given way to the rude intertwining of the woody fibres of the softer parts of plants. Amongst barbarous tribes at the present day, we find, however slender may be their habiliments, that these are generally composed of some forms of the woody fibres of plants. These fibrous garments are composed, however, of materials essentially different from cotton; and when we examine the simplicity of the means of procuring and manufacturing the one as compared with the other, we cannot but feel that the introduction of cotton as an article for making wearing apparel indicates a very considerable advance in civilization. For the purpose of understanding the difference between cotton and other fibrous materials, we must enter a little into the history of the structure of plants.

All plants are made up of two kinds of tissue, one called vascular, the other cellular. They both originate in the same processes of growth. The vascular tissue is composed of long fibres, which lie together in bundles, and form the hard and elongated parts of plants. If we take a leaf and examine it, we find a number of ribs passing off from each side of the leaf-stalk, which is prolonged into the leaf. These ribs are composed of vascular tissue; and if we take a leaf and pull one of these ribs to pieces with a couple of needles, and place it under the microscope, we shall easily discern the long fibres of which it is composed. Such fibres are found in the bark and stems of plants (pl. xi., figs. 26 and 27); and if we take any delicate plant and treat it as we did the leaf, we shall find the same fibres. When these fibres are plain and straight, without any markings, they are called plain vascular tissue, or woody fibres. Now, it is these fibres, abounding in the bark and stem of the flax-plant (pl. xi., fig. 25) and the hemp-plant (fig. 24), which yield the material of our linen and hempen manufactures. The fibres of a vast number of other plants are used in various parts of the world for the same purposes. In this country we employ the fibres of New Zealand flax (fig. 23), of jute, Manilla hemp, and cocoa-nut (fig. 22). The vegetable kingdom presents us with an infinite store of these fibres, and many more plants will undoubtedly contribute their share, as advancing civilization causes their properties to be better understood and appreciated.

Cellular tissue, which consists of variously-shaped cells united together, everywhere fills up the interstices formed by the vascular tissue (figs. 26 and 27). It also covers over the whole of

the outside of the plant, forming what is called its epidermis (fig. 23). It is in this epidermis that we find the little pores called stomates, which allow the fluids absorbed by the roots of plants to pass out. It is also upon this epidermis that we find growing those little projections which give a character to the surface of plants, as warts, hairs, prickles, and the like. In this respect the plant is like the animal, for it is from the epidermis of the animal that we find those appendages formed which we know by the name of scales, hairs (fig. 28), feathers, quills, and so forth.

All these epidermal organs in the plant are composed of cellular tissue. The cells of these hairs are very delicate and feeble, and possess very much less power of resistance than the woody fibres. However long these hairs may be, they never possess strength enough for manufacturing purposes. They will not bear the twisting that is necessary to the production of a thread which can be woven. Many plants yield long hairs, as our own cotton-grass (fig. 19) and the silk-cotton (fig. 20) tree of the West Indies; but it is found impossible to twist them into a thread for the manufacture of textile fabrics. It is, then, very strange that we should find cotton belonging to this group of vegetable organs. Nevertheless, this is the fact. The cotton fibre is a hair: it does not, however, grow on the surface of the plant. Just as we find in animals, the epidermis continued into the internal cavities of the body from the outside, so we find the epidermis of plants continued into the interior of their fruit and on to the surface of the seeds. This is a very rare occurrence; but in the case of the cotton-plant, it produces in the interior of the fruit, upon the surface of the seeds (fig. 16), a longer and stronger hair than any found upon the external surface of plants. But it is not the length nor the strength of the hair alone which gives to it the power it possesses of forming a thread when twisted. If examined under the microscope, the cotton-hair will be found apparently to consist of two delicate transparent tubes (fig. 15),—the one twisted round the other, so as to have the appearance of two pieces of cord wound round each other. If, however, the hair be examined in its young state, it will be found to be an untwisted cylindrical tube. It is during its growth that this change takes place. As the seeds and hairs grow, the capsules do not appear to expand with equal rapidity; and, consequently, the hair is exposed to pressure on all sides. The result of this is, that the hair collapses in the middle, leaving a half-formed tube on each side. These uncollapsed portions of the hair give it the "appearance," says Bauer, "of a flat ribbon with a hem or border at each edge." The hair does not, however, grow out straight, but, coming in contact with other hairs and the sides of the cap-

sular fruit, it becomes twisted; thus acquiring the appearance at first described, of two cords twisted together.

This twisting is undoubtedly the great fact that makes the cotton-hair of value to man. There are many hairs, such as those of the Cotton-grass and of the Bombax, which are as long, and, apparently, as strong as those of the Gossypium ; but which, failing in this irregularity of their surface, are utterly incapable of being twisted into a thread or yarn. The twisting then gives the capacity to the cotton-hair of uniting with its fellows, and forming together a cord strong enough to be woven. If we place a portion of cotton thread under a microscope, we shall see that the projections of one portion of the hair are received into the depressions of the other, and thus they are held together by the natural inequality which has been produced on the cotton-hair by its peculiar method of growth. It is, perhaps, not unworthy of a moment's reflection, that the staple manufacture of one of the greatest countries in the world, and the principal produce of another, should depend upon the apparently accidental irregularity on the surface of a hair. But this is not accidental; the form of the cotton-hair depends upon the same forces, and is determined by the operation of laws as grand as those which arrest our attention in the movements of the physical universe. The observation of such phenomena as those of the structure of the hair of a plant, and its connection with the social and commercial conditions of two great countries like England and America, should lead to the reflection that it is to a considerable extent upon the minute and accurate study of the laws and properties of the objects in the world in which man is placed, that God has caused his material happiness and advancement to depend.

The manufacturer values cotton according to its *length*, *strength*, and *silkiness*, and the longest, strongest, and softest cotton fetches the highest price. These qualities are easily judged of by the hand and eye. At the same time it has always appeared to me, that as at least the qualities of strength and silkiness must depend on properties that can be easily observed by the microscope, this instrument might be of important use in ascertaining those qualities which render cotton of value to the manufacturer. I have been supplied with a series of commercial cottons by Mr. W. Chambres, of Liverpool, and having placed them under the microscope, I find considerable difference in the appearances which they present. The long Sea-Island cotton is a flatter and less twisted hair than any of the cottons of inferior price. I have not been able to pursue the subject so as to arrive at any positive results; and rather refer to the subject here to induce some of the readers of the *Popular Science Review* to undertake the subject, with the view of detecting the dif-

ferences which exist between the high-priced and low-priced cottons, and those which are useful for one purpose rather than another.

The hairs of the cotton plant are made of the same materials as all other parts of the plant. Whether the tissues of plants are ultimately disposed in the form of cells or of vessels, the raw material of their construction is the same. The cells and vessels of plants are made of a material called *cellulose*,—at least, this is the name given to the matter out of which cotton-hairs are formed. When we take a piece of wood, and, sawing it, collect the dust and obtain the chemical substance out of which the vessels that formed the wood were made, it is called *lignine;* and when the cells get very hard indeed, as they do in cherrystones, the material is called *sclerogen.* But these three things differ but little from one another; and the first name will serve us to distinguish everywhere the matter out of which cells are formed, and which is found in those of the hairs of cotton. Cellulose is insoluble in water, either hot or cold. Herein it differs from the material out of which animal cells are formed, for this is soluble in hot water, and is called *gelatine.* It is the insolubility of cellulose which makes it so useful to man in the manufacture of textile fabrics, and in the building of houses and ships. Although insoluble, it is easily convertible into starch. By pouring sulphuric acid on to cotton-hairs we can convert them into starch. It was at one time the dream of the chemist to be able to convert deal boards into Suffolk dumplings; but the feat has yet to be accomplished. Nevertheless, cellulose can be detected by its ready conversion into starch, and its affording then the reaction of starch with iodine. This experiment may be readily performed with a piece of paper, which is cellulose.

This cellulose, then, has a definite chemical composition, and can be changed in its properties and qualities by combining it with other things. One of the most remarkable chemical changes which it undergoes is its conversion into a rapidly combustible agent by the action of nitric and sulphuric acids. If we take a quantity of cotton, and immerse it in a mixture of these two acids, and then take it out and wash it in water and dry it, we shall find that, chemically, its character is entirely changed; although, under the microscope (fig. 18), it has lost little of its original appearance, its inflammability has vastly increased. It is, in fact, *gun-cotton.* We are indebted for the discovery of this agent to Schönbein, the Swiss chemist, whose name is so familiar as the discoverer of ozone. Gun-cotton is technically called *Pyroxylin*, a name significant of its combustible nature. Cellulose consists originally of nearly equal proportions of carbon, oxygen, and hydrogen; but, by plunging it in the acids,

it is deprived of a large proportion of hydrogen, and nitrous acid takes its place. The consequence is, that so large a quantity of oxygen is contained in the compound, that the moment it is brought in contact with heat, the oxygen combines with the carbon and hydrogen, and an immense quantity of carbonic acid gas and vapour of water are formed, and an explosion is the result.

Pyroxylin differs from gunpowder in many respects. In the first place, it ignites at a temperature of 400° Fahr., which is 200° less than the degree of heat at which gunpowder explodes. Then its explosive force is three times as great as gunpowder. On this account it is not adapted for guns; it blows them to pieces, and has, after all, a less propulsive effect on the ball. Nevertheless, for blasting, gun-cotton is very useful, and is much employed at the present day. It has also this advantage in mines—the gases it produces are less injurious than those produced by gunpowder. It resists the action of water, and, if plunged into it, or exposed to the action of damp air, it regains its explosive force by drying.

Pyroxylin has many curious chemical properties, an account of which my limited space will not permit me to give; but there is one so interesting, on account of its practical importance, that a natural history of cotton would hardly be complete without mentioning it. I allude to the solubility of gun-cotton in ether: it is insoluble in water and in alcohol, but it is soluble in ether. When dissolved thus, it is called *Collodion.* When collodion is spread on any surface and exposed to the air, the ether evaporates, and a delicate transparent film of pyroxylin is left. When iodide of potassium is added to collodion, and spread on a glass plate, and then dipped into a solution of nitrate of silver, an iodide of silver is formed, which, on being exposed to the action of light, undergoes a change of colour. By these means sun-pictures, formed by the camera, may be impressed upon the plate. These, properly prepared, become the negative plates by which the photographer multiplies, on sensitive paper, the pictures he has taken. Here again we trace the reward following upon diligent search into the properties of natural substances.

The study of the chemical properties of the cotton-hair has not only led to the multiplication of natural pictures, but to the reproduction, at a cost which places them within reach of almost the poorest in the land, of the great works of genius which no mere copies of natural objects can equal.

Before leaving the subject of the cotton-hair, there are one or two other points to which I would refer as worthy of notice and investigation. It is well known that vegetable fabrics receive different impressions from the colouring substances with which they are dyed. Cotton, hemp, and jute, when

exposed to the same dyeing agents, do not present the same colours, and these are again very different from the colours received by animal substances. This probably depends on the action of the colouring substance on the materials of which the fabrics dyed are composed. In the cotton it has been observed that the dye is not diffused through the wall of the cell forming the hair, but that it passes through the cellulose envelope, and is deposited in the interior. It would be interesting to know more on this subject, as it is probable that some kinds of cotton, whose structure might easily be made out by the aid of the microscope, receive into their interior with greater facility than do others the colouring matters which constitute their value after having been submitted to the calico-printer.

One of the most remarkable applications of a knowledge of the action of chemical substances on cotton is the process invented by Mr. Mercer for modifying its fibre. This process consists in the steeping the cotton-hair in a solution of caustic soda. The effect of this is, to alter not only the microscopical appearance of the cotton-hair, but also to change the chemical character of the cellulose. The cotton, when placed under the microscope, after having been submitted to the soda, assumes a tubular appearance, losing its flat, ribbon-like, and twisted character. The cotton thus affected is also found to have its relation changed to the various dyes to which it is submitted. Under these circumstances, it is much more easily dyed, and exhibits brighter colours than when in its unchanged state. This process is extensively employed in the manufacture of cotton stockings, more especially for foreign markets. The stockings are first made loose, and after submersion, they contract, and assume a much smaller and more elegant form. This process does not appear in any manner to interfere with the strength and durability of the manufactured article.

Another point of some interest is the chemical composition of the ashes of the various kinds of cotton-hair. It is well known to the vegetable physiologist, that certain salts or mineral substances enter into the composition of the tissues of plants, and, unless these substances are supplied to the soil, the plants will not flourish. It is on this principle that the farmer now applies phosphate of lime to his land, because his cereal crops will not grow so well without it. This constituent is present in the grains of wheat, and is conveyed to the bones of man from the flour of wheat, which he eats in the form of bread. The sugarcane requires silex, or flint, in its stems, and the sugar-cultivator has found it of advantage to manure his crops with powdered glass, which contains the silex needed by the sugarcane. I throw out this suggestion because circumstances might occur to render it of im-

portance to supply artificially to the soil the constituents necessary for the production of the cotton in its greatest perfection. It may be found that the difference between the production of the most valuable cotton and that of an inferior description, depends on the supply of those mineral constituents to the soil which are necessary to the proper development of the cotton-hair. It has been stated that the ashes of the finest Sea-Island cotton contain a larger proportion of the salts of potash, whilst inferior kinds contain larger quantities of soda. Such facts are of high interest to the cotton cultivator, and seem to point out the way of securing the better qualities of cotton.

But let us now turn our attention to the history of the plants which produce this wonderful hair. The genus of plants which yield cotton is called by the botanist *Gossypium*. This word, which is the Latin word for cotton, is said to be a corruption of the Egyptian word *gotne*, which is evidently a form of the Arabic *kutun*, and has its origin in the same root as our word cotton. This botanical genus *Gossypium* embraces several species, four or five of which have been named by botanists as affording the cotton of commerce. The family or group of plants to which the genus *Gossypium* is referred, is the Malvaceæ or Mallow tribe. This family of plants is remarkable for its showy flowers, and embraces about thirty-five genera in addition to Gossypium. Some of these are well known. Besides the common mallow and the round-leafed mallow, which are common on all our waysides, the marsh-mallow is a British species. In our gardens the hollyhock is a familiar example of the size, and beauty, and colour of the flowers of this order. If we examine one of the flowers of these plants, we shall find that a distinguishing feature of them is that the stamens are all united together, forming a column in the middle of the flower, which is hollow in the centre, and surrounds the styles, which proceed from the germ or ovary in the middle of the flower. These columnar stamens are characteristic of the family; but there is a further mark of brotherhood in this Mallow family, and that is, the anthers having but one cell. Usually the anthers, which are placed at the top of the filament of the stamens, have two cells or compartments, in which the pollen-dust is kept; but in the Mallow tribe each stamen keeps its pollen in a single cell. There are many other points of structure about these plants which, conjoined with the above, make up very strong family features. One of these is worth notice, and that is, the arrangement of the petals. If a mallow is gathered before its flowers are opened, and the sepals of the calyx are removed from the petals, it will be found that the petals assume the appearance of having been twisted. It looks

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precisely as though some one had taken the young petals between his finger and thumb, and given them a twist, just such a twist as a confectioner gives to the corners of a paper bag, when he has placed in it the articles he wishes to secure by this process. This is called a "twisted æstivation," and such an arrangement may be seen in the flowers of the hollyhock, the cotton, the marsh-mallow, the abutilon, and other common plants of the order.

The genus Gossypium is distinguished among other genera of the order by three leafy bracts outside the flowers, which are united at their base (pl. x., figs. 1, 2, 3), and by the seeds being covered with hairs (fig. 6). The following are the species which have been recognized, and which are known to yield the cotton of commerce:—

1. *Gossypium herbaceum* (fig. 3).—This is the common Cotton-plant of India, and is probably the original source of the hairs from which the first cotton fabrics were manufactured. It is called herbaceous, because its stems are not so woody as in the other species. It is a pretty plant, and rises from eighteen inches to two feet in height during the first year of its growth. It is usually cut down annually, but, if allowed to grow, the plant attains a height of five or six feet, and its branches become more woody. The younger parts of the stem, as well as the flower and leaf-stalks, are covered with hairs, and are also marked with black spots. The leaves are also hairy, but the hairs are very short, and different from those on the seed. The flowers of this plant are of a lively yellow colour, and each petal is marked with a purple spot near the base. These plants are described as very beautiful when in blossom. The large mass of columnar stamens is also conspicuous in the middle of the flower when it is open. The flowers are succeeded by a fruit, which gradually becomes dry, and then bursts into three or four valves, when the cotton-wool is seen issuing from the fruit in all directions. When the wool is cleared away from the seed, there will be found upon it a downy substance, which consists of a series of smaller hairs on the surface of the seed (fig. 16).

This plant not only yields a good proportion of the shorter cottons of India (fig. 10), but it is found in China and the Malayan Peninsula, and also in Egypt. A species named *Gossypium punctatum* is found in Senegambia, which is probably a variety of the *Gossypium herbaceum*. It is cultivated on the borders of the Mediterranean, and has been introduced into some parts of America.

There is a curious tendency on the part of some cotton-plants to produce a yellow or tawny cotton instead of white. This is the case with much of the cotton that is produced in

China. The colour has been no hinderance to its employment for manufacture. It receives the same dyes as white cotton; but when it is not dyed it has that yellow colour which is peculiar to what is called "Nankeen" in this country, when it is made up. This name has probably been given to it from the Chinese origin of this kind of cotton. The question has arisen as to whether the plant which produces this tawny cotton is not another species, and botanists have described it under the name of *Gossypium religiosum*. The Chinese plant which yields the yellow cotton is very like the Indian plant. It is described as being more hairy, and having its flowers of a darker yellow or brownish colour. Dr. Royle, who is one of our greatest authorities on cotton-plants, says that other species of cotton, besides the Chinese, produce tawny cotton, and he does not believe in this character as a distinction for the species of cotton.

This question of species might, at first sight, be thought an unimportant one; but when it is remembered that species are peculiarly adapted to the circumstances in which they are found, and will not submit to a change in their culture so easily as varieties, it becomes a matter of practical importance to solve such a question. The fact that the Chinese form has been successfully introduced into those parts of the world where also the Indian species flourishes, would indicate that they are varieties of the same primitive type.

2. *Gossypium arboreum* (fig. 2).—This is another Indian species, and is called the Tree Cotton. It is a very different plant from the last. It grows to the height of from fifteen to twenty feet, and assumes the aspect and dimensions of a small tree. The young and growing parts of the plant, like the rest of the species, are covered with hairs, and the young branches have a red colour. The leaves are palm-shaped, hairy, and dotted with spots of a dark green colour. The flowers are of a bright red colour, getting a little yellowish towards the lower part. These red flowers are very characteristic, and when the tree is in full blossom, give it the appearance of a branched hollyhock with red flowers. The fruit is a dried capsule, similar to that of the last species, opens with three or four valves, and is filled with a fine silky yellowish-white wool. In this case, the seeds are covered with a greenish down, in addition to the wool. The seeds in the different species of cotton differ very considerably in their colour, and in the presence of this short down; they vary also in number. The Tree Cotton is found in the island of Celebes, and is distributed through every part of India. This cotton is not, however, employed generally in the manufacture of cotton cloth, as it is regarded by the Faqueers of India as a sacred plant. It is therefore planted near temples, and also sur-

rounding habitations. The cotton makes a very fine muslin, which is manufactured into turbans, and permitted to be worn only by the privileged religious classes of India.

3. *Gossypium barbadense* (fig. 1).—This is called the Barbadoes or Bourbon cotton, but does not appear to have been originally a native of the New World. It is a perennial plant, and has a shrubby stem from six to fifteen feet in height. The leaves are lobed like those of the other species, and are often covered with short hairs on the under surface. The flowers are yellow, like those of *Gossypium herbaceum*, and have a dark spot at the base of each petal. The fruit is capsular, and contains in its interior from eight to twelve black seeds, which are not covered with any down like those of the two preceding species. Although other names have been given to the plant which produces the long Sea-Island, or long staple cotton of America, there is no doubt that this plant is the original of this valuable form of cotton. It was introduced into Georgia by seed brought from the Bahama Islands, where it had been grown from seed obtained in the West Indies. In the small American islands which fringe the coast of Georgia, from Charleston to Savannah, this plant has produced the celebrated Sea-Island cotton, which is unrivalled for the length of its staple, its strength, and silkiness (fig. 14). Its excellence for manufacturing purposes may be judged of by the fact that its price has varied from fifteen pence, at this time last year, to three shillings a pound at the present time, whilst other cottons have varied from five pence last year to about thirteen pence a pound at the present time.

The cotton which is of such excellent quality on the islands and swampy coasts of Georgia, is inferior when cultivated in the cooler and drier climates of the hill country of that state. The cotton produced in those districts is short in staple, and the seeds, instead of being black, are green. This fact shows how great is the influence of external circumstance on the successful growth of the cotton-plant. The cotton from the hills of Georgia is known in the markets by the name of Upland or *Bowed* cotton. This latter term is applied to it on account of the way in which it is prepared for the market. The wool is separated from the seeds by means of a bow with several loose strings, which is struck upon the cotton, and the vibrations produced separate the cotton from the seed. The price of Bowed cotton was last year at this time, at Liverpool, seven pence a pound; at the present moment it is worth a shilling a pound.

Under the name of *Gossypium hirsutum*, Dr. Royle and other botanists describe a species, which, although it has characters that would claim for it such a position, is, nevertheless, open to the suspicion of being a variety. It is in fact the plant

which yields the Upland cotton of the Americans. It has the short staple and green seeds of the Upland Georgia cotton, and which there is reason to believe originated in the culture of the *Gossypium barbadense*. The principal distinction upon which the botanist relies for a specific difference, is the green colour of the seeds, which is found to depend upon the presence on the surface of the seed, of the pubescence or short hairs which have been before alluded to. In the typical *Gossypium barbadense* there is no pubescence, nothing but the long cotton-hair, underneath which the seed is black.

4. *Gossypium Peruvianum.*—The Peruvian Cotton-plant, also described as *Gossypium acuminatum*, is recognized by most botanists as a distinct species. Like the Bourbon cotton, it has black seeds and yellow flowers. The seeds adhere together, however, in a peculiar way in a kidney-shaped mass; and although in other respects it resembles the last species, it has a peculiar appearance, and cannot in any way be traced to the species of the Old World for its introduction. On the conquest of Peru and Mexico by Pizarro and Cortes, it is worthy of note that in both countries the inhabitants were found to have acquired the art of weaving cotton. The species of plant from which this cotton was obtained was the present one, which is undoubtedly the only species truly indigenous in America. It is this which yields the Pernambuco and Maranham cottons of the markets. After the Sea-Island and Egyptian, these South-American cottons obtain the highest price in the market.

It becomes an important matter to ascertain what are the conditions under which the various species of cotton-plant thrive, as we can only hope to extend its culture successfully by ascertaining the external circumstances under which it has prospered, and securing them for future experiments. In the first place, with regard to *heat*. We find that the cotton flourishes best in the tropics; but its culture has been successfully extended in warm districts, in both south and north subtropical climates. It has been produced in great perfection in Egypt (fig. 9), and the islands of the Grecian Archipelago; and cotton equal to the finest Sea-Island has been produced at Algoa Bay and in Australia (fig. 13).

A second element which seems to exercise an important influence on the growth of cotton, is *moisture*. The humid atmosphere that prevails along the coasts of Georgia seems to be the circumstance, above all others, that has led to the great superiority of the Sea-Island cotton. That this is the case we may observe from the fact of the same plant, when taken to the dry uplands, producing a very different and inferior kind of cotton. It has been stated that the atmosphere of the coasts of America contains in it a considerable quantity of salt, or chloride of sodium,

and that this produces a favourable effect on the cotton. If this should really be the case, it would point to the propriety of seeking for cotton-fields on the seacoast rather than in the interior of a country.

As far as the *soil* is concerned, we find that the American and Indian species grow on very different soils. They both, however, agree in this point, that they contain a considerable quantity of organic matter, of a substance which is known commonly as mould, or to the chemist as humus. This material, wherever present, constitutes the most valuable constituent of a soil. It is highly absorbent, and supplies the plants whose roots are inserted in it, with the carbonic acid and ammonia which they need for the growth of their tissues. The inorganic or mineral constituents of the American soils, according to analyses by Professor Solly, consist of sand, clay, iron, and carbonate and sulphate of lime. These are the kind of constituents that we should expect to find on the low coasts of the shores of America. Such an analysis may guide in the selection of soils for the purposes of experimental cultivation. The Indian soils, on the other hand, on which the Indian species grow, are composed of the *débris* of trap rocks, of clay and limestone. It appears from experiments that have been made, that the *Gossypium barbadense* will not flourish on the Indian soils (fig. 11), whilst the *Gossypium herbaceum* will not flourish, or at least improve, when transplanted to American soils. This shows clearly the necessity of attending to the external circumstances which influence the growth of the cotton. This, we have seen, is not only necessary for the whole genus, but for each particular species. It is probable that the same circumstance applies to varieties, and that in the purchase and planting of seed, too much care cannot be taken to ascertain that the new circumstances of the plant should as nearly as possible resemble those in which it has previously flourished.

The great question for this country to settle at the present day seems to be, How and where shall we secure cotton for our manufactures independent of America? There can be no doubt that the wisest and most patriotic reply that can be made to this question is, "In our own colonies and dependencies." Amongst these, India presents itself as capable of affording by far the largest supply; and it is a question of great interest to ascertain why India has not furnished the market with larger and better supplies of cotton. At the present moment Indian cotton fetches the lowest price in the market. It has a short staple, and is not brought into the market so clean as that from other parts of the world. It is, however, a serviceable cotton. A longer stapled cotton might evidently be obtained by cultivating the American species of cotton in soils adapted for its

successful growth. The cleaning it, is a matter which enterprise and intelligence ought to accomplish.*

Africa, no doubt, presents on its northern, western, and southern coasts, soils and climates adapted to the growth of cotton. Many years ago I forwarded specimens of cotton, which had been grown at Port Natal, to Manchester, and they were pronounced of excellent quality. The great difficulty, however, which Africa presents is that of securing a permanent supply of labour. The native population is everywhere too rude in its habits to be depended on for producing any large quantities of a produce requiring so much attention for its culture as cotton. It will be a happy day for Africa when its inhabitants shall settle down to the permanent production of those substances so universally needed by man, and which its soil and climate are so capable of yielding in almost any quantity.

To the West Indies we ought to look. Our own islands there were the first recipients of the plant which now supplies Manchester with its best cotton. Till the year 1786 we received above a third of all our cotton from the West Indies; and there appears to be no valid reason why we should not receive a larger quota than this at the present day. Soil and climate are favourable to the production of cotton equal to the Sea-Island (fig. 12); and there are only needed the enterprise, skill, and determination which have enabled the Southern statesman of America to obtain for his cotton access to all the markets of the world. Let it not be said that slavery is essential to the growth of good cotton, as it is very evident that this is an accident, and not a necessity of cotton culture.

The only other country to which it is necessary here to draw attention is Australia (fig. 13). Upon the coasts of this vast country there must be innumerable localities in which cotton would find all the conditions of its most prosperous growth. Already specimens have been seen in this country, and a high authority has pronounced that "cotton equal to the finest of the fine might be produced to an almost indefinite amount" in Australia. A new experiment must, however, be tried there before cotton cultivation can succeed, and that is the ability of the white labourer to meet the conditions necessary for the cultivation of a plant whose natural climate lies within and a little beyond the tropics. This difficulty may not be insurmountable, and we may yet be indebted to Australia for a commodity more precious than gold.

* Since the above was written, my attention has been called to some letters by Dr. Wight, on the subject of the culture of cotton in India, in the "Gardener's Chronicle" for December, 1861, which claim the consideration of all those interested in the culture of cotton in India.—E. L.

DESCRIPTION OF PLATES X. AND XI.

Fig. 1. American cotton-plant (*Gossypium barbadense*).
2. Tree cotton (*Gossypium arboreum*).
3. Indian cotton (*Gossypium herbaceum*).
4. Pod of American cotton bursting.
5. Pod of Indian cotton.
6. Seed from Abyssinian cotton.
7. Ditto of American cotton.
8. Pod of American cotton.
9. Bundle showing the length of staple of Sea-Island cotton (*G. barbadense*) grown in India.
10. Ditto of native Indian cotton (*G. herbaceum*).
11. Ditto of New Orleans cotton grown in India.
12. Ditto of West-India cotton.
13. Ditto of American cotton (*G. barbadense*) grown in Australia.
14. Ditto of fine Sea-Island cotton.
15. Fine Sea-Island cotton under the microscope.
16. Outside of seed of cotton, showing the down, together with the cotton-hair.
17. Surat cotton (*G. herbaceum*).
18. Gun-cotton.
19. Hairs of cotton-grass (*Eriophorum vaginatum*).
20. Hairs of Bombax.
21. Fibres of jute.
22. Cocoa-nut fibres.
23. Fibres of New Zealand flax, with a portion of the cuticle of the stem, and a stomate in it.
24. Fibres of hemp.
25. Fibres of flax.
26. Transverse section of stem of flax, showing the bundles of woody fibre in the cellular tissue.
27. Transverse section of stem of hemp, showing ditto.
28. Wool of sheep.
29. Fibres of silk.

GRASS.

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"He bringeth forth grass for the cattle, and green herb for the service of men."—PSALM civ. 14.

WHEN an untravelled Englishman takes his walk across the wide-stretched parks of his native land, or strolls over the green meadows of the nearest village, or even if his view be confined to his garden lawn only, he will hardly be aware that the turfy carpet, to which he is so accustomed, cannot be equalled in the evenness and regularity of its pile, or the greenness of its colour, in any other country under the sun.

But should our countryman go abroad, he will hear on all sides from those foreigners who may have visited England, the highest laudations of our parks and lawns; and when he is weary of foreign scenes, and sighs for home, he may know, if he but carefully scrutinise his thoughts and feelings, that his native meadows more than all besides are at the bottom of his longings, as they afford that refreshing repose to the eye and peaceful calm to the mind, which cannot be found elsewhere in an equal degree.

If again, our friend should inquire more deeply, and wish to know to what he is indebted for so much beauty, we could tell him that its immediate cause is an even, steady, luxuriant (but not rank) growth of a series of grasses, which know how to live side by side, each tending to the other's good; and while it is quite true that here and there may be seen some upstart kind trying to overtop the rest, and get a plot of ground all to itself, yet be sure there is no sweetness there, for even the quiet sheep would shun it.

But there is yet something more. Our temperate climate, in spite of all that may be urged against its mist, its east winds, or drizzling rains, has not those extremes of heat or cold, of rain or drought, which belong to other countries, and which render that continued growth of turf that we enjoy impossible.

Spicate Grasses

Thanks then to the Divine Author of all Good, green parks, flowery meads, and closely shaven lawns, belong to our climate, and this affords us, after all, no small balance in its favour.

Seeing, then, that the grass of the field is so important an element in all that is English in scenery, and is besides so interwoven with the economics of our daily life, we purpose devoting a few pages to the illustration of the *structure*, *classification*, *habits*, and *economy*, of the useful tribe of plants to which grasses belong.

Time was when most herbaceous plants were known by the general term of grass, and even in the present day, plants very different from those we are about to describe, are familiarly known by the word grass as a prefix, or affix, thus :—

Grass of Parnassus, (*Parnassia palustris*); scurvy-grass, (*Cochlearia officinalis*) ; rib-grass,* (*Plantago lanceolata*).

Science, however, insists upon a more natural arrangement, and so confines the term grass within the following description :—

Endogenous plants, with chaffy scales in place of floral envelopes (calyx and corolla). The outer pair of scales, called *glume*, or outer pale,—the *calyx*. The internal pair called *glumel* or inner pale,—*corolla*. Stamens, usually three; pistils, mostly two; *stems*, fistulose jointed—that is, a hollow jointed tube; leaves, sheathing.

As a botanical group, there is none more natural, and yet none more varied; but such variations are of the most simple kind, and when once understood, the study of this tribe of plants, far from being considered one of a difficult kind, will really become comparatively easy; for as the observed variations mostly arise from a difference in the *proportions* of parts, if we start with correct notions of the *organography* of a single species, we can have but little difficulty in applying our knowledge to the examination (analysis) of all others.

The chief distinctions of grasses may be classed under the following heads :—

a. In the size and details of the parts of the flower.
b. In the length of the *pedicels*, or the flowering stems, by which each individual flower, or bunch (*locusta*) of flowers, is immediately supported.
c. In the general size of the whole grass.

In order, then, to understand these points, it will be necessary

* One of our students was showing a farmer a collection of *all* the meadow grasses, when the latter took occasion to observe that the rib-grass was absent.

shortly to review the parts and organs, which are found in our native species of grasses. They will be as under :—

ANALYSIS OF A GRASS.

Root		*a.* Fibres	The true root fibres.
Stem.		*b.* Rhizome	The creeping underground stem.
		c. Stolon	Shoot, or runners above ground.
		d. Culm	The upright above-ground stem.
		e. Joint	A single length from node to node.
		f. Node	The solid knot between the joints.
Leaf.		*g.* Sheath	The folding portion of a leaf.
		h. Ligule	The tongue of a leaf.
		i. Blade	The lamina or free part of a leaf.
Floral Envelopes.		*j.* Glume	The outer chaff-scales } in pairs.
		k. Glumel	The inner ditto } in pairs.
		l. Awn	The bristle (beard) of some species.
Fertilizing Organs.	Stamen.	*m.* Filament	The thread supporting the anther.
		n. Anther	The pouch containing the pollen.
		o. Pollen	The farina or fertilizing dust.
	Pistil.	*p.* Style	The support of the stigma.
		q. Stigma	The tip or end of the style.
		r. Seed	The reproductive organ.

N.B.—The letters to the analysis refer to the plates, except *a*, *b*, *c*, and *o*, which are sufficiently explained above.

Now these terms, with their references to our figures, will, it is presumed, be amply sufficient to indicate the parts of a grass referred to, without any more minute description, as it is no part of our plan to dwell upon the minute anatomical distinctions, or morphological theories that necessarily belong to this subject, which would then be rendered an abstruse rather than a popular one.

It may be well, however, just to mention that some of the parts in the foregoing analytical table will be absent in some species; their absence or presence will afford specific characters, and these are further enhanced by the different details of different parts, as whether the valves of the glume be pointed or obtuse, ribbed or plain, or those of the glumel awned, awnless, &c., &c.

With these notes on the organography of grasses, we proceed to the consideration of our next point of inquiry.

2. THE CLASSIFICATION OF GRASSES.—In treating of this subject, we would again repeat that our remarks have immediate reference to our native species. These we shall find, with the exception of three, to possess three stamens and two pistils. The exceptions are—

Anthoxanthum odoratum, sweet vernal grass, stamens 2, pistils, 2. *Hierochloe borealis*, northern holly-grass, terminal flower with stamens 2, pistils 2, lateral ones triandrous.

Nardus stricta, mat-grass—stamens 3; pistil 1.

The rest in our list of British grasses, consisting of about 40 genera and 120 species, belong to the Linnæan, *Class* Triandria; *Order*, Digynia.

Fig. a.

These it is necessary to divide into smaller groups, which may readily be done upon the following principles, dependent upon—1st, the arrangement of the flowers; 2nd, the form of the inflorescence.

1st. With regard to the relation of the glume-scales to those of the glumel, it becomes now necessary to remark that there is not always a pair of the former to each pair of the latter, as in this respect we find three points of difference, as follows:—

a. Each glume having a single flower; that is, glumel, stamens, pistil, and seed.
b. Each glume having two flowers, or two sets of glumellæ, stamens, pistils, and seeds; that is to say, that each bunch (*locusta*) of flowers consists of two florets to the single glume.
c. Each glume possesses three or more sets of glumellæ, stamens, pistils, and seeds; or, has three or more florets to a single glume.

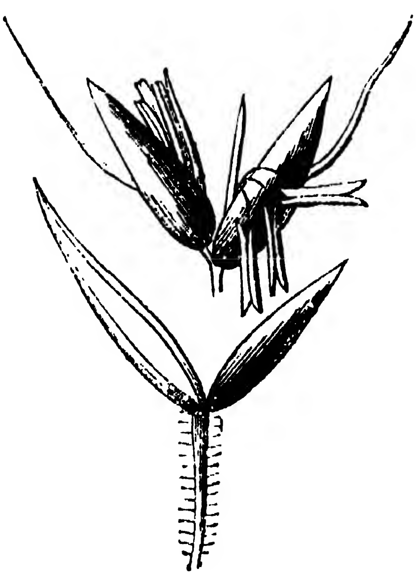


Fig. b.

Fig. c.

2nd. A point of importance to be here observed, is that of the form of the inflorescence, as thus: each flower, or locusta of flowers, may be so closely set on the central column (*rachis*) as to form a compact head, or "spike," which may have the

florets on one side, or "unilateral," like *Nardus*, or hard grass (pl. xii., fig 1). On two sides "bilateral," as in *Brachypodium*, false brome-grass (pl. xii., fig. 2). Or on all sides, as *Alopecurus*, or foxtail grass (pl. xii., fig. 3), which forms a long or "lanceolate spike," as in *Phalaris canariensis*, canary grass (pl. xii., fig. 4), making an ovate spike.

Again, the flower or locusta may have pedicels of greater or less length, which may be short and upright, long and pendant; and so form a compact or diffuse "panicle" of flowers, which will be erect or drooping, towards *one* or *all sides*, according to circumstances. (See plate xiii.)

Of the different kinds of spike, our plate (xii.) offers several examples, whilst plate xiii. offers examples of the panicle.

Our native grasses, therefore, may be most conveniently grouped as follows :—

A. Stamens, 2; Pistils, 2;
B. Stamens, 3; Pistils, 1;
C. Stamens, 3; Pistils, 2;

† *Spikelets, single flowered;*
* Flowers spiked;
a. Spikes unilateral;
b. Spikes bilateral;
c. Spikes, with flowers on all sides;
** Flowers paniculate;
†† *Spikelets, two flowered;*
*** Flowers spicate;
**** Flowers paniculate;
††† *Spikelets, with three or more flowers;*
***** Flowers spicate;
****** Flowers paniculate.

Thus, we have subdivided our native grasses into nine groups, which altogether include a list of genera and species that must be expected to vary considerably, according to the principles of founding both genera and species that may be adopted by different authors,—a subject upon which, it will be seen from the following census, that there is considerable difference of opinion :—

	Genera.	Species.
Sir W. Hooker, in the "British Flora," 1842, has .	41	123
Hooker and Arnott's "British Flora," 1850, has .	44	129
Professor Babington's "British Botany," 1851, has .	50	131
Bentham's "Handbook of the British Flora," 1858, has	42	98

Whichever number we choose to adopt as our guide in the enumeration of our native species, it will be seen that, after all, in a country so justly renowned for its pasturage, the native species form but a small proportion of the grasses of the world,

Paniculate Grasses

which, according to Professor Lindley, amount to 291 genera, containing 3,800 (?)* species.

But this will appear in a still stronger light when we consider that, after all, the fame of the English pastures rests upon about 20 genera, including no more than 40 species, and that, even of these, probably all but about a dozen would be better out of the pasture than in it. In concluding this part of our subject, however, we would not have it supposed that grasses only are useful in the meadow, for it is well known that several herbs, and more especially the clovers, are highly valuable as part of a pasture; indeed, so much so, as to be called by the farmer "artificial grasses," a term which, after all, seems to imply a secondary position compared with the real *Graminaceæ* which, though so few in species, are yet the plants which so much charm the admirer of English rural scenery, and are at the same time of such great economic value.

3. Habits of Grasses.—We have just seen how few of this tribe of plants occupy the meadow as pasturage, and, indeed, these are not exclusively meadow-plants, for their habits are so varied as to fit them for almost every situation. Thus we have—

		Species.
Jungle or Bush Grasses, Rocky Places, &c.	about	40
Aquatic, or Water Grasses	„	10
Marine, or Sea-side and Salt Marsh Grasses	„	14
Meadow, or Pasture, or Herbage Grasses	„	35
Agrarian, Fallow, or Weed Grasses †	„	23

Now, if we estimate the number of grasses of the meadow kinds at about twenty species, we shall find that such disorders in the pasture as want of drainage, will introduce a number of the aquatic kinds, whilst a pasture being allowed to run wild will also give rise to a quantity of the jungle forms, which gradually become a part of what can only be considered as rough wild herbage.

Again, if we divide meadows according to their quality, we shall find that they contain different species, in very varying proportions, for which see the following table :—

* This note of interrogation is employed by Professor Lindley in "The Vegetable Kingdom." We must, therefore, take these figures as merely approximate.

† These numbers are derived from an allocation of the species figured in "English Botany."

TABLE.—*Showing the Relative Growth of Grasses in different Situations.**

1. Botanical name.	2. Trivial Name.	PROPORTIONAL. 3. Upland Pastures, thin Soils.	4. Poor Clays.	5. Rich Loams.	6. Flooded Meadows.	7. Irrigated Meadows.	REMARKS.
1. Alopecurus pratensis	Meadow foxtail	—	1	2	2	3	Very variable in growth, increasing rapidly as the soil becomes better.
2. Phleum pratense ...	Timothy grass	—	2	2	1	2	In poor land only about 9 in. high, 2 feet in good soil.
3. Agrostis stolonifera	Marsh bent	2	—	—	1	2	Occurs in all poor uplands, where it is generally refused by cattle. Spreads rapidly under irrigation, when it becomes a good grass.
4. Arrhenatherum avenaceum	Oatlike grass	—	3	1	—	—	Never abundant, except in poor soils either of clays or sands.
5. Poa pratensis	Field meadow-grass ...	1	1	2	1	3	In most meadows.
6. „ trivialis	Roughish meadow-grass	—	—	—	2	1	Increases quickly in stagnant meadows; decreases under perfect irrigation.
7. Briza media	Quaking grass	1	2	—	—	—	Only in poor soils.
8. Avena pubescens ...	Soft oat-grass...	1	—	1	1	1	Tolerably constant in meadows.
9. „ flavescens ...	Yellow oat-grass	—	—	1	1	2	Most abundant in good soils.
10. „ pratensis ...	Narrow-leaved oat-grass	1	2	—	—	—	Often abundant in poor heathy land.
11. Holcus lanatus ...	Meadow soft grass ...	1	1	—	2	—	Increases rapidly in stagnant or marshy meadows, not usual in good pastures.
12. Festuca ovina	Sheep's fescue	4	—	—	—	—	Almost entirely an upland grass.
13. „ duriuscula..	Hard fescue	2	1	1	—	1	Also an upland form, but occurs more or less in most places.
14. „ rubra (var.)	Creeping fescue	—	—	2	—	—	A form, though not frequent, in rich meadows; also in sandy pastures near the sea.
15. „ pratensis ...	Meadow fescue	—	—	2	1	1	Abounds in good pastures.
16. „ loliacea ...	Spiked fescue...	—	—	1	2	2	Very fine in floods' way, on the banks of the Isis, at Oxford, and on the Churn, near Cirencester.
17. Bromus erectus ...	Upright brome-grass ...	1	—	—	—	—	Belongs peculiarly to calcareous uplands.
18. Dactylis glomerata...	Cocksfoot-grass	—	1	2	3	3	Of general occurrence; increases rapidly in good soils.
19. Hordeum pratense...	Field barley-grass ...	1	1	2	2	2	Often in patches in the richer parts of uplands. Very abundant in the hay-fields in the valley of the Churn.
20. Lolium perenne ...	Perennial rye-grass ...	1	1	3	2	2	In most pastures. In uplands it seldom attains to 6 in. high; it is double that in good deep pastures.
Amount of hay per acre	Average	—	10	15	25	30 to 40	
Rent per acre	Average	10	15	25	30	40 to 100	

* From the "Natural History of British Meadow and Pasture Grasses." Hamilton & Adams.

In this table are arranged twenty species of the usual meadow grasses; it will be seen that they differ under varying circumstances of soil and condition of the meadow; each species of this tribe of plants becoming, as it were, an index of the nature and cultivation of the soil; for if the latter be neglected there will soon be a change, not only in the species and their proportion of meadow grasses, but gradually there will be introduced those of the jungle list, until the meadow itself, by continued neglect, would resolve itself into jungle, heath, or moor land.

Our beautifully shaven lawns and green meadows, though so characteristic of merry England, are not natural to the country, but are, after all, the result of cultivative skill acting in accordance with those natural conditions of soil and climate which favour their development, and this consideration introduces us to the next division of our subject.

4. THE ECONOMY OF BRITISH GRASSES.—It is often repeated that, "he is a benefactor to his country who makes two blades of grass grow where one did before,"—a remark, of course, more particularly directed to the farmer and the country gentleman, many of whom may be justly lauded for having attempted, with some measure of success, to realize the position. Still, however, these interesting plants have been so little studied, that, after all, the progress of improvement in meadow is, and has been for a long time, nearly at a stand-still; and at the present moment the pastures of England are little more than half as productive as they ought to be, many being in need of drainage, and more requiring weeding.

Now, it may interest the popular reader to be told that some of the most mischievous weeds in meadows are grasses themselves; still, if we could but instil into the minds of those whom it concerns, that whatever takes up space without contributing nutritious matter, can only be regarded as weeds, then the rough grasses that multiply just in proportion as a meadow is out of order would be looked upon with disfavour, and as some of these kinds arise from *wet*, others from poverty, and many from neglect, the study of the natural history of this tribe of plants is calculated to inform us of every condition of soil and cultivation, even in their most minute inflexions. That meadows should be overrun with rushes, wild parsley, docks, plantains, dandelions, and buttercups, exhibits want of care; and the great prevalence of these is tantamount to a waste of land and loss of grass; for "two things cannot occupy the same space at the same time." This is not the place, however, to enlarge upon what may be considered to some extent a professional matter, and so leaving their cultivation to those concerned in it, we draw our brief survey of the grasses to a close by say-

ing that they are in themselves so beautiful, so diversified in their structure and habits, and in every way so interesting and useful, as to render their natural history well worthy of popular study.*

Before concluding, it may now be not without value if we give a few directions with regard to the collection and preservation of specimens. As the forest shades, the rocks, moorlands, salt and fresh water, meadows, and agrarian fields, have all their graminaceous denizens, no part of a district or country should remain unexplored; the specimens when obtained should be placed evenly and neatly between sheets of blotting paper, or even in old newspapers, and then put between boards and pressed with straps, or with some weight. Care should be taken to keep the specimens of the proper size for the permanent herbarium, which may be done either by cutting them into lengths, where too long, or by bending them.

It is also of importance to see that the papers of one day's collection are not put with those of the day previous, and so that three or four boards would be advisable to separate one lot from the other; for it is obvious that if a fresh lot be placed along with those that are already partially dried, the former will communicate their moisture to the latter, and then mouldiness will result. The permanent herbarium should consist of a portfolio, or of separate sheets of cartridge paper, about eighteen inches long, and eleven wide.

The summer collection and arrangement of grasses cannot fail to impart health to the body and vigour to the mind; and when winter comes, and our favourites are no longer in their prime, how pleasantly our herbarium recalls our many agreeable rambles, and as we then look out, it may be, from the windows of our cheerful country-house, and behold our parks and meadows now brown and seared, which once were so gay with waving grass, we may reflect with the Psalmist:—

"The days of man are but as grass, for he flourisheth as the flower of the field.

"For as soon as the wind goeth over it, it is gone: and the place thereof shall know it no more."

* We recently had the pleasure of examining some large and beautiful collections of our wild grasses, which were made under such interesting circumstances that we cannot forbear referring to the fact. The Messrs. Wheeler, seedsmen, of Gloucester, having for some time become aware of the importance of a personal acquaintance with the plants, the seeds of which they sold, offered prizes for competition among their commercial travellers, clerks, and warehousemen, for the best collection of wild grasses. The result was a very spirited contest, which led those engaged into scenes of beauty they would perhaps not otherwise have visited; and this made them acquainted not only with the appearance, but also with the habits of a tribe of plants, the observation of which, we venture to say, is better calculated to discipline the mind than is that of any other group in the vegetable kingdom.

EXPLANATION OF PLATES.

Plate XII.—Examples of Spicate Grasses.

Fig. 1. Unilateral spike (*Nardus stricta*).

2. Bilateral spike (*Brachypodium pennatum*).

3. Compact lanceolate spike (*Alopecurus pratensis*).

4. Oval spike (*Phalaris canariensis*).

N.B.—The letters refer to the names of parts in the "Analysis of a Grass," p. 188.

Plate XIII.—Examples of Paniculate Grasses.

Fig. 1. Upright panicle of *Bromus mollis*, var. *racemosus*.

1′. Glumel of ditto ($\frac{4}{1}$).

2. Ditto of *Aira caryophyllea.*

3. Diffuse panicle of *Briza minor.**

3′. Enlarged locustæ of ditto.

4. Drooping panicle of *Poa nemoralis.*

N.B.—The letters refer to the names of parts in the "Analysis of a Grass," p. 188.

* This drawing was made from a specimen most kindly communicated to me, with other rarities, by H. C. Watson Esq., of Thames, Ditton.

HISTORY OF THE REFLEX THEORY.

BY G. H. LEWES.

"IT is my conviction," says Professor Bennett, "that when the bitterness of personal opposition has subsided, the impartial world of science will award to Marshall Hall the honour of not only originating, but of establishing, and practically applying to the treatment of disease, one of the most important physiological doctrines discovered since the days of Harvey."* Several other testimonies to the like effect may be read in the same volume, which have induced me to write the history of the doctrine in question, not only with a view of assigning to Marshall Hall his real position, but also of adding a chapter to the history of our knowledge of the nervous system. As the estimate I have been able to form of Marshall Hall is by no means of that exalted kind which will constantly be met with in the pages of his Memoirs, it may not be wholly superfluous to state, that in no sense can "the bitterness of personal opposition" apply to me, since I never saw the distinguished physiologist, nor did I ever come into any personal relation with him, direct or indirect. I shall leave it to history to show that he did not originate the Reflex Theory, and that, so far from having "established one of the most important doctrines since that of Harvey," the doctrine has long been given up by every physiologist of repute in Europe; and that the Reflex Theory now generally established, positively rejects all that Marshall Hall claimed as his discovery.

What is the Reflex Theory? This is the first point to be settled. To state it briefly, we may say, that it is an attempt to describe the *mechanism* by which certain acts in the living body take place without consciousness; and to connect with this same mechanism, all those acts in decapitated or brainless animals which *look* like acts prompted by sensation and volition, but which *cannot* be so prompted—it is held—because sensation and volition are seated in the brain. If a man be in a state of complete unconsciousness, from the pressure of a bit of bone on his brain, so that he neither sees, hears, nor feels, this cessation of cerebral activity does not prevent his breathing, swallowing, &c. The chest expands, the œsophagus contracts on being stimulated, the heart beats, the intestines move,—these and numerous other nerve-actions go on nearly as well

* "Memoirs of Marshall Hall." By his Widow (p. 117).

without the brain as with it; and even when the brain is present, and uninjured, these actions mostly take place without exciting any sensation. How is this?

Aristotle, and the earlier physiologists, made short and easy work of it. According to them the soul moved the body, and every action was due to an impulse of the soul; *how* the motion was effected no one attempted to explain. As, however, it appeared that the mind was not conscious of some of these impulses, the hypothesis was formed of three different souls or three forms of the one soul (the rational, the sentient, and the vegetative), which severally presided over the functions of intelligence, volition, and nutrition. This hypothesis was deemed so satisfactory that it reigned undisturbed until the middle of the seventeenth century. To the modern physiologist, it seems nothing but a re-statement of the original difficulty: it gives a name to the cause of the phenomena of growth, volition, and intelligence, but in no sense does it explain the phenomena—in no sense does it unveil the cause. Indeed, the mechanism of nervous phenomena was scarcely suspected at this period.

Our own Willis was the first to sketch this mechanism. His exposition of the nervous system, in man and animals, made an epoch; and although his physiology is encumbered with "animal spirits," "subtle atoms," "flames," and other superstitions of his day, it is a great advance on what had previously been taught. The problem we have at present before us he solved by the hypothesis of two souls—one, the *anima*, or sensitive, corporeal, igneous soul of brutes, which presides over all the organic processes, as well as over all instincts, emotions, and involuntary acts; and another, the *animus*, or rational, immaterial, immortal soul, which is the exclusive appanage of man; the *anima* man shares with brutes, the *animus* is his peculiar prerogative. It would lead me too far to detail the anatomical mechanism which Willis has assigned for the functions of these souls, or his attempt to localize perception in the *corpora stricta*, imagination and appetite in the *corpus callosum*, and memory in the convolutions of the *cerebrum*;* enough for the present to indicate that he made the nervous system the *instrument* of the rational soul, and the *body*, so to speak, of the sensitive soul.

Stahl, less of an anatomist, and more of a metaphysician, admitted but one soul—the rational. To it he assigned all the actions of the body. As to the obvious objection that the soul was quite unconscious of many impulses necessary to organic life, he replied that this was quite consistent with his view. He

* See particularly *De Animâ Brutorum*, i. cap. iv. (*Opera*, ed. 1676, vol. ii. p. 36.)

profoundly saw that the mind does not always reflect upon its acts; some of its most indubitable acts are performed unconsciously.* This conception of the soul as tantamount to both mind and vital principle still finds ardent advocates; and this very year an eminent professor (Tissot) has published a thick volume ("La Vie dans l'Homme") which may be called an amplification of Stahl's hypothesis.

But we are seeking the organic *mechanism,* and these hypotheses will not assist us. The dawn of the discovery is in Unzer's celebrated work, which the "Sydenham Society" has made generally accessible, through Dr. Laycock's translation.† Unzer not only collected a mass of interesting facts relative to the actions of the nervous system, but discriminated them with great precision, and attempted to determine their mechanism. He classed all the phenomena under the two heads of sentient actions (*actiones animæ*), and nerve-actions—the latter being wholly *independent* of sensation.

It is true that the only proof of their being independent of sensation is that they may be seen in brainless animals; which, as I have elsewhere shown, is no proof at all.‡ "Thus," he says, "a decapitated animal will stand, move forwards, raise itself up, leap, fly, flutter its wings, seek food, clean, defend or conceal itself, &c. A decapitated man, immediately after decapitation, struggles to free his hands, attempts to stand upright, and to stamp with his feet. If the head of a pigeon be cut off whilst it is running, it continues to run on for some distance until it knocks against something; a frog leaps forward without its head; a snake, a fish, a worm, writhes and twists about, if touched, although wholly deprived of sensation; a fly makes a movement of brushing its eyes by a natural instinct, although its head be cut off; a headless snail seeks its food by its usual plan of feeling about; a decapitated tortoise does the same thing, and will live for half a year after decapitation, and raise itself up, or endeavour to do so, if placed on its back; an earwig nips with the nippers of his abdomen at its own separated head, when the head bites the abdomen; in short, all the instinctive actions of animals are sometimes seen to occur as nerve actions; and it naturally follows that they occur as such, at first in newly-born animals, and that it is only after the perception of external sensations that they become sentient actions." Here we perceive that the reason why these actions are excluded from sensation is because

* STAHL: *De Mechanismi et Organismi Diversitate.*

† UNZER: *The Principles of Physiology.* PROCHASKA: *A Dissertation on the Functions of the Nervous System.* Translated by Thomas Laycock, M.D.

‡ The Reflex Theory, and the evidence on which it is based, are fully discussed in the "Physiology of Common Life," vol. ii.

the perception of external sensations is removed by removal of the brain. Unzer thinks that the brain is the seat of the soul, and it is impossible for any other organ to have a sensation. Hence he remarks, "a headless tortoise lives several months; *it cannot possibly feel the sensation of faintness from an empty stomach;* yet the external impressions must change the vital movements contra-naturally like that painful sensation, because it becomes feeble and faint from starvation. The digestive organs must be excited to the movement, which are requisite to digestion, by the external impressions of emptiness, just as by the instinct; since the bowels are moved peristaltically and the digestive fluids are secreted."

Having thus proved, as he thinks, that many actions take place without sensation, because they take place without the brain, Unzer ascribes to a similar mechanism all those actions of which we are unconscious: in such cases the impressions on the sensitive nerve are not transmitted to the brain, but are *deflected* from their course, and excite the muscles, without having reached the brain. "What prevents the propagation to the brain?" he asks. "There is nothing to be found in the nerves adapted to this end, except certain formations found scattered on the nerves, termed ganglia." This conjecture may or may not be accepted, he says, "still the fact remains, that external impressions on certain nerves excite movements without reaching the brain and without being felt." Replace this hypothesis of the ganglia on the nerves, as the centres of deflection, by the hypothesis of the spinal centres, and the modern Reflex Theory is before you; not indeed the theory of Marshall Hall, but that of his successors.

Prochaska is the next name on our list. As far as my own investigations and meditations enable me to understand this complex subject, Prochaska seems most nearly to have approached to a philosophical and systematic explanation, however erroneous some of his details may be. He alone, since Stahl, has seen the necessity of making *all* the nervous centres seats of *sensation*, and the brain the seat of *ideation*.* "However composite the machine of the nervous system may be," he says, "I think it may be divided into three portions, just as its functions are most conveniently ranged under three divisions; namely, in the first place, the animal organs (or the organs of the *mental* faculty), the cerebrum and cerebellum; secondly,

* CÆSALPINUS held this view: "Ibi esse animæ principatum *ubi origo est nervorum;*" it is true that he, believing the heart to be that origin, immediately adds, "Sed hoc cerebrum esse, non dicet nisi is qui crassè hæc contempletur."—*Peripateticarum Quæstiones*, 1571, p. 108. WHYTT had arrived at the conclusion that the whole, and not a part, of the nervous system, was the seat of the mind; but he placed reason in the brain and sensation in the nerves.—(*Works*, p. 288—note.)

the *general sensorium*, which appears to consist of the medulla spinalis, medulla oblongata, together with that portion of the cerebrum and cerebellum from which the nerves directly arise; and thirdly, the nerves themselves."

This luminous conception of the general *sensorium* being co-extensive with the origin of all the nerves, and not confined to the brain, or to some particular part of the brain, was unhappily not in harmony with the views then general. Had it been adopted, I cannot but think that we should now have been much further advanced than we are. Be this as it may, for the present we have to show its bearing on the Reflex Theory. "The external impressions," he says, "which are made on the sensory nerves, are quickly transmitted along the whole length of the nerves, as far as their origin,"—that is to say, as far as the spinal centre, or sensorium,—"and *having arrived there they are reflected by a certain law*, and pass on to certain corresponding motor nerves, through which, being very quickly transmitted to muscles, they excite certain definite motions." He adduces a number of examples,—sneezing, coughing, winking, convulsive movements of epilepsy, retraction of pricked limbs, and all the actions in decapitated animals; so that it was impossible for any one, conversant with his work, not to see that he had anticipated much of what Marshall Hall claimed to have discovered. Accordingly, the charge of plagiarism was raised against Marshall Hall, and much heartburning was excited. But, on this point, Hall is certainly blameless. It is true that Prochaska had explained reflex phenomena, had named them reflex, and had assigned the spinal chord with the sensory and motor nerves, as the mechanism by which they were effected. But, in the first place, Prochaska's views had fallen into utter neglect; and, in the next place, Marshall Hall's theory was, in some respects, different from that of Prochaska. So complete was the neglect, that when Marshall Hall declares he had never heard of these views, until his critics challenged his originality, we are bound to believe him; we are bound, by the general principle, that the word of an honourable man is not lightly to be doubted; and by the overwhelming presumption against the likelihood of his having seen Prochaska's work. His critic in the *British and Foreign Medical Review* asserted that if Hall's denial were true, such ignorance was "discreditable to him as a scholar;" he ought to have been acquainted "with so striking a work as that of the Professor of Prague." Now, as far as my researches extend, *no* eminent physiologist, English or German, had taken any notice of Prochaska's views. Rudolphi, one of the most eminent and erudite, does indeed include Prochaska's anatomical tract, *De Structura Nervorum*, (which has nothing to do with the reflex theory,) in his bibliography; but he mentions no other work, and makes no

allusion to Prochaska's opinions.* Gall mentions and cites Prochaska, but had evidently paid no attention to his physiological views, since he does not even allude to them.† Richerand and Majendie, the two leading physiologists of France, know not even Prochaska's name. Johannes Müller, the Haller of our day, had quite forgotten, if he had ever known anything of Prochaska; and, in yielding the priority to Marshall Hall, never suspected that a countryman of his own had already promulgated the theory. The erudite Dr. Thomson, in 1832, the very year before Hall announced his discovery, in his account of Continental physiologists who had advanced our knowledge of the nervous system, never mentions Prochaska.‡ Nay, even J. W. Arnold, writing after the theory had become European, in giving a sketch of Hall's predecessors, mentions Unzer, but says not a word about Prochaska.§

There can be but one conclusion from these facts: the work which such physiologists overlooked, we may readily suppose was unknown to Marshall Hall, especially in days when access to German works was incomparably more difficult than it is now. While I wholly acquit him of plagiarism, I cannot but think that he acted ungracefully in not recognizing Prochaska's priority when once it had been pointed out, the more so, as he might still have vindicated his own originality. There is manifest injustice in the common tendency to deprive a man of his claims to our gratitude by ransacking old archives in search of some phrase, or some forgotten theory, which reads like an anticipation. On this point one may say with Malpighi (who, by the way, is the original discoverer of many modern discoveries) that where a discovery has passed out of men's minds, and is as dead as if it had never been born, he who reproduces it is entitled to the reward of an inventor, "dicitur nova inventio illa, quæ licet fuerit cognita alicui præteritis seculis, nihilominus de ea apud posteros nulla extitit memoria, quia cum illa non pervenerit ad nostram cognitionem pro usa nostro, est tanquam nunquam extitisset." || Very often the anticipation is a mere phrase, a vague guess, or a suggestion not followed up; sometimes it is a real vision, but is so far in advance of the science of the day as to attract no notice and admit of no application. Nothing can be more evident than that Hooke and Mayow had very clearly and scientifically explained the phenomena of combustion and respiration; nevertheless, when Lavoisier and Priestley, by similar experiments, established similar theories, a century later, their fame was not diminished

* RUDOLPHI: *Grundriss der Physiologie*, ii. 1823.
† GALL et SPURZHEIM: *Anat. et Phys. du Système Nerveux.* 1810.
‡ THOMSON: *Life of Cullen*, vol. i. 1832.
§ ARNOLD: *Die Lehre von der Reflex Function.* 1842.
|| MALPIGHI: *Opera Posthuma*, 1697, p. 5.

by the priority of Hooke and Mayow. We may say the same of Prochaska and Marshall Hall. Had not Lavoisier and Priestley, or some one else, established their theories, no mention would have been made of Hooke and Mayow, except as curious experimenters. Had not Marshall Hall and Müller made the Reflex Theory a European doctrine, we should not have heard of Prochaska; for, as I have shown, the Reflex Theory had no existence among scientific doctrines; it had not attracted even the notoriety of a doctrine considered to be absurd.

During the half-century which elapsed between Prochaska and Marshall Hall, the subject was approached by another route, namely, the investigations into the spinal chord, which became gradually of great importance. It will surprise the student of our day, aware of the large place occupied in physiology and pathology by the phenomena assigned to the spinal chord, to see how little notice was taken of it only a few years ago. Two indications will suffice. Richerand's Physiology, which was long accounted as the first of text books, has no notice whatever of the spinal chord, in the edition published in 1807; and the work of Rudolphi, published in 1823, out of an entire volume given to the nervous system, devotes but one page to the spinal chord, and that is occupied with discrediting the ideas of Legallois, who made it a sensorial centre. Nevertheless, as I said, experimentalists were busy. In 1803, J. J. Sue advanced the hypothesis that the spinal chord was capable, to some extent, of replacing the functions of the brain.* In 1812, Legallois published his celebrated work,† wherein this idea of Sue's was developed and confirmed by very striking evidence, showing that, in the absence of the brain, the chord became a centre of sensation and volition; showing also that separate portions of the chord were separate centres, having separate bodily actions under their control. In 1817, Fray‡ declared the chord to be the organ which presided over all the internal economy, which during walking and sleeping regulated all the organic actions, and acted as their sensorial centre. In the same year, Wilson Philip § also maintained the sensorial character of the spinal chord. In 1822, Sir Gilbert Blane opposed this idea, and denied that the actions of decapitated animals, as well as the instinctive actions of sucking or breathing, were prompted by sensation. He held the brain to be the exclusive seat of sensation, and was consistent in his view that all instinctive and automatic actions were independent of sensation.||

* Sue: *Recherches sur la Vitalité.*
† Legallois: *Expériences sur le Principe de la Vie.*
‡ Fray: *Essai sur l'Origine des Corps organisés et inorganisés.*
§ Wilson Philip: *Inquiries into the Laws of the Vital Functions.*
|| Gilbert Blane: *Croonian Lecture in Select Dissertations.*

Thus the path was cleared for Marshall Hall. Ample evidence had been collected to prove that there were other centres of nervous action besides the brain; that the phenomena which depended on these centres were those actions usually styled instinctive and automatic, and those observed in decapitated animals; and that these centres were situated in the spinal chord and medulla oblongata. While some thought that these centres were sensorial, others said, No: they insisted on the brain only being capable of "sensation;" so that all acts which were not dependent on the brain, were said to be divorced from consciousness. In 1833 Marshall Hall first disclosed his theory, which was briefly this:—There is a distinct class of actions, called reflex actions, wholly independent of sensation or volition. These belong to a *distinct* nervous mechanism, "the true spinal system," with a *separate* set of nerves, the excitor and the motor nerves. An impression on the surface is conveyed by an *incident, excitor* nerve to the spinal centre, and, instead of being transmitted upwards to the brain, is immediately *reflected* along the *motor* nerve to the muscle.

On comparing this with Prochaska's statement, it will be seen that the only differences are in denying the presence of sensation, and in supposing the existence of a separate anatomical mechanism, "the true spinal system." The first of these differences is a matter of opinion on a point wholly incapable of proof, but in which the presumptive evidence is, I conceive, wholly against Marshall Hall. The second of these differences is an hypothesis, which Hall never attempted to prove anatomically (though his distinguished disciple, Mr. Grainger, attempted it for him), and which is universally *rejected* by all Europe.

Thus, although Marshall Hall has the credit of having revived (not originated) the Reflex Theory, and, by his more precise application of it to various physiological and pathological phenomena, has given it a new importance in the eyes of the scientific world, his claims as a "discoverer" are reduced to that of a systematizer. That which was *new* in his theory is now universally rejected as erroneous; that which was *true* in it was known to others. But he systematised and placed in a striking light what was confused and obscure; he made the Reflex Theory the doctrine of the schools. Such is the verdict which the impartial world of science will deliver; and if it is somewhat different from the verdict prophesied by Professor Bennett, it is quite in accordance with what a physiologist, greatly his superior, has delivered:—"The facts had been witnessed and reasoned upon by various physiologists," says Professor Sharpey, "but to Dr. Marshall Hall belongs the credit of having fully shown the connection with each other, of having first successfully generalized them, and of having given to this part of physiology the form of a consistent doctrine; and

to him belongs exclusively the merit of applying a knowledge of these phenomena to pathology." *

Even had Prochaska never lived, and as far as Hall is concerned we are bound to consider him as non-existent, the sole claim which can be made to a discovery is founded on the true spinal system, with its separate sets of nerves. That is Marshall Hall's own; and that is an error. All the rest belongs to others. That it does belong to others is seen in the fact that the Reflex Theory, divested of this hypothesis, was simultaneously promulgated, as a novelty, by Johannes Müller, who, on a comparison of dates, at once awarded to Hall the priority of publication. But Müller had no new facts to adduce; he simply generalized the known facts, respecting the action of the spinal chord; and connecting them with the assumption of the brain being the sole seat of sensation, he declared the independence of the spinal chord, and the absence of sensation in its special acts.

But while history thus irrefragably shows that Marshall Hall made no discovery at all, even if Prochaska's claims be set aside, and that it is therefore preposterous to compare him with Harvey, who revolutionized physiology, and *demonstrated* that which no one before him had suspected,—whereas Hall demonstrated nothing but what was already well known,—still I think that science was greatly benefited by the zeal, the energy, and the ability with which Marshall Hall worked out the Reflex Theory, and applied it to the explanation of many physiological and pathological facts. It is only necessary to compare the state of our knowledge now, with its condition when he first published, to see what an immense advance has been made, much of which is certainly due to the discussion of points raised by him. Even the hypothesis of a separate spinal system, erroneous as it was, proved of great service, like many other erroneous hypotheses: it gave a definite direction to research. And if his successors have bit by bit destroyed all that was peculiar in his statement of the Reflex Theory, extending and modifying the theory to suit the advance of knowledge, and leaving it much more like the theory advanced by Prochaska; we must nevertheless remember that it is owing to Hall's striking hypothesis, and more systematic arrangement of known facts, that successors, in a great measure, have been enabled to improve upon his theory.

To sum up, we may say, that if Marshall Hall was not a great man, he was a distinguished man, and has "deserved well of his country."

* SHARPEY, as quoted in Hall's *Memoirs*, p. 109. And compare, also, what MARSHALL HALL himself admitted in his first paper, presented to the Royal Society, p. 659, and in his *New Memoir*, p. 87.

SOLAR CHEMISTRY.

BY ROBERT HUNT, F.R.S.

"THE fable of Prometheus is but the outshadowing of a philosophic truth," was the language used by Lavoisier to express his belief in the direct dependence of all organization on influences derived from the Sun. Every advance which has been made in the examination of this most interesting subject, proves that *energies* originating in that vast globe, determine the phenomena of life on this earth, and regulate nearly all the conditions of the inorganic world.

Situated at the enormous distance of upwards of ninety-five millions of miles from us is this great orb, having a diameter of 882,000 miles, which forms the centre of the solar system. Not only is the Earth and each of the other planets chained to the Sun by the attractive power of its mass, but their motions are determined by its motion, and the physical forces which regulate all cosmical phenomena have their source within its body. The Sun, figuratively termed "the fountain of Light," is equally so, of every other Power with which science has made us acquainted. An infinite store of creative energies is amassed in the solar orb. These are diffused in obedience to the Creator's word, and flow for ever throughout the universe, to be absorbed by the planetary spheres, producing alike, the crystalline arrangement of rock masses, and the development of vital forms.

"Man," says Bacon, "is but the minister and interpreter of nature, and can neither extend his power nor his knowledge a hair's breadth beyond his experience and observation of the present order of things." Entirely acquiescing in this, we feel, nevertheless, that we have scarcely yet recognised the vast power of the human mind. Guided aright, man can penetrate the arcana of space, and dive into the tomb of time. With telescopic eye he can reach the worlds remote in space, and study the chemistry at work within them, while his microscopic vision enables him to detect the presence of the minutest monad, and watch the kindling of life's faintest spark. Although, as we have said, there are more than ninety-five millions of miles of space between this Earth and the Sun, the human mind has bridged the gulf, analysed the solar matter, and shown how, in all probability, the physical forces are developed. To explain this as clearly as possible is the purpose of the present paper.

Since the time when Newton analyzed the solar beam, the

advance of our knowledge has been rapid. We know of luminous rays which were never seen by that philosopher. Of the chemical action of light he was ignorant. The beautiful phenomena of the Polarization of Light were unknown to him, and of the existence of numerous *dark lines* crossing even the most brilliant divisions of the Newtonian spectrum—and which promise to advance our knowledge by the discovery of many sublime truths,—he had not the most remote idea. Yet, notwithstanding this want of the knowledge with which we are familiar, Newton possessing, in a remarkable degree, that power of thinking out a truth, which showed itself so strongly in the philosophers of Athens, proposed an hypothesis, which has been set aside and almost forgotten, but to which we are now returning, to adopt it as the most truthful theory of the physical condition of the Sun.

With the following quotation from Newton's "Optics," let us fairly introduce the inquiry, which, with every advance, appears to confirm his views:—

"May not great, dense, and fixed bodies, when heated beyond a certain degree, emit light so copiously,—as, by the emission and reaction of their light, and the reflections and refractions of their rays within their pores—to grow still hotter, till it comes to a certain period of heat, *such as is that of the Sun?*

"And, are not the Sun and fixed stars great earths, vehemently hot, whose heat is conserved by the greatness of the bodies, and the mutual action and reaction between them and the light which they emit?"—(*Newton's Optics.*)

Since Newton's days, this hypothesis for a considerable period was discarded, and more especially so, since Sir William Herschel gave to the world his investigations on the solar spots. The prevailing idea has been that the Sun is a dark mass; that floating above it there exists a stratum of opaque clouds; and that surrounding—enveloping—those is the *Photosphere*, or sphere of light, whence we derive the luminous powers on which vision and colour are dependent.

Arago and Biot determined, by a series of beautifully devised experiments, dependent on the phenomena of the polarization of light, and by careful observations, that the luminous principle, originating in the photosphere, is produced by a gaseous or vaporiform medium in a state of intense combustion. This discovery did not, however, interfere with the idea that the mass of the Sun was dark and cold. It is only within a very recent period that inquiries in a new direction have taught us to doubt the correctness of the views originating with the elder Herschel, and have led us back to the speculations of Newton.

To explain these modern investigations, it will be necessary to examine with some care the known conditions of the solar agencies, and some of the peculiar phenomena of Light.

If through a pin-hole made in a window-shutter a sunbeam is allowed to pass into a dark room, three phenomena are rendered evident to our senses. LIGHT, producing vision and developing colour, is shown upon every particle of dust floating in the luminous pencil. HEAT is sensibly felt, if the hand is placed in the path of the ray; and ACTINISM, or *chemical power*, is rendered evident by the change produced, if we allow the beam to fall on any photographic preparation. That the sunbeam should have the power of breaking up the strongest combinations depending on chemical affinity, is one of the wonderful discoveries of science. Now, if we place a triangular prism of glass in the path of the sunbeam, the rays are bent out of their course, or refracted, and by this means decomposed into a beautiful flame-like chromatic image. If this solar spectrum—this section of a rainbow—is received upon a screen, it will be found to consist of several coloured bands; crimson, red, and orange passing into yellow from the least refracted end, while from the most refrangible one, we have lavender, violet, indigo, blue, and green, also passing into yellow, as they advance to the true centre of the spectral image.

These rays constitute the Newtonian spectrum; so-called from Newton's having first examined, with precision, the relative conditions of these coloured bands, and established, with any approach to correctness, the laws regulating the relations of colour and refraction.

Beyond the most refrangible end of this spectrum there exists another class of rays, which are not visible under ordinary circumstances. If, however, the rays of Light are intercepted by solutions of sulphate of quinine, or of horse-chestnut bark,—by a block of canary-yellow glass, coloured with the oxide of uranium, or by a crystal of fluor spar, those extra spectral rays are rendered apparent. Those rays, which were unknown to Newton, have been investigated by Professor Stokes, who has named them the *Fluorescent rays*. They are luminous, probably under all circumstances, to those animals whose eyes are adjusted—as the eyes of most of the night-roaming creatures are—to admit the rays of highest refrangibility, and to vibrate in unison with their vibrations; but, unless peculiar conditions are established, the fluorescent rays are not sensible to the human eye.

Such, then, is the amount of our knowledge respecting the luminous principle of the sunbeam. It must not be forgotten that the rays of which we have been speaking vary considerably in the intensity of their illuminating power. The maximum

exists in the Yellow ray, and it diminishes as we recede from it towards either end of the spectrum. The least refrangible, or the Red rays, give a modified amount of Light; but the maximum of Heat exists in them. The most refrangible, or Blue end of the spectrum, is less luminous; but the maximum of chemical action is fixed at this extremity, the fluorescent rays beyond the spectrum of Newton being visible only under the peculiar circumstances mentioned.

When these beautifully coloured bands of Light are well defined upon a screen, let the inquiring reader examine the image with a small telescope. A new set of phenomena will become apparent. The spectrum is then seen to be crossed by a vast number of *black lines*. Every ray, even the most brilliant, will be seen to have spaces in which there is an entire absence of light. To these we would now direct attention.

It is instructive to trace the steps by which we slowly advance to the discovery of a great truth. As in ascending a tall column, the way may, for a season, prove dark and possibly —being without promise—wearying; but, eventually, the gleams of light are seen, and presently a wide horizon is opened to our view. Thus has it been with this inquiry.

Dr. Wollaston was the first who observed the existence of non-luminous spaces in the prismatic spectrum. Dr. Ritchie proved that these lines were dependent on absorption, and showed how they could be *increased in visible numbers by artificial means*. Fraunhöfer, however, was the first to make a full investigation of these lines, and to publish a map of them; hence they have been generally called Fraunhöfer's lines.

These lines are of so fixed a character in relation to the coloured bands of the spectrum, that if it is desired to indicate with great precision any special ray of the spectrum, we refer to them by their letters or numbers. In the accompanying plate, the more remarkable lines only are given. The positions they occupy have been determined, by a careful examination of the map of Fraunhöfer, and the very complete delineation of those lines published in the "Philosophical Transactions for 1859," by Sir David Brewster and Dr. Gladstone. Fraunhöfer laid down on his map 354 lines, but Sir David Brewster says—"In the delineations which I have executed, the spectrum is divided into more than 2,000 visible and easily recognized portions, separated from each other by lines more or less marked."

The lines marked with capitals from A to I in the plate may be always easily detected in any Solar spectrum. Those which are indicated by small letters, and those which are numbered, are the more marked lines observable in Sir D. Brewster's map; the letters and numbers agreeing with those which he employs.

The origin of the dark lines—spaces in which there is no Light—can scarcely be said to be yet resolved. Fraunhöfer, and

others following him, thought that the Light emitted from the photosphere was, from the first, deficient in those rays, or that they were lost, either by absorption in passing through the solar atmosphere, or possibly in passing through that of the Earth. Angstrom,—who also discovered many *bright lines* in the spectra from artificial lights,—advanced some highly philosophical views in 1855; but the investigations of Bunsen and Kirchoff, remarkable alike for the delicacy and caution observed in the inquiry, and for the refined nature of their deductions, lead us probably up to the true explanation of these phenomena. The dark lines of the Solar Spectrum, and the bright ones observable in the spectra obtained from artificial lights, have been investigated by Professor Wheatstone, Dr. W. A. Miller, Mr. Fox Talbot, and Sir John Herschel. These investigators have proved that the spectra obtained from the Light emitted from incandescent mineral bodies differ from that obtained from the Sun; that the lines from artificial sources of Light are, in many cases, peculiar; and that, in the majority of instances, *bright lines* appear to take their place. So rigidly exact were the positions and characters of the lines obtained from differently coloured flames, that both Wheatstone and Miller suggested the adoption of spectral or prismatic analysis, as a means of determining the presence of exceedingly minute quantities of any substance. The investigations of Bunsen and Kirchoff have, from their high interest, again drawn attention to this subject. These lines, *dark* and *bright*, have been employed in the analysis of the solid mass of the Sun itself; and the extreme delicacy of the indications is proved from the discovery, by Bunsen, of two new metallic bodies—one called *[illegible]æsium* (meaning bluish gray), and the other [illegible]*ium* (from the Latin *rubidus*, which was used to express [illegible]rkest red-colour), which existed in infinitesimally small quantities in some mineral waters of Germany.

By the beauty of the new phenomena observed, and by the boldness of the deductions drawn from the experiments made, the greatest additional interest has been added to this class of investigations. The discoveries, it must not be forgotten, have been arrived at by a series of steps, every one of them of the utmost importance, and it cannot but be regretted, that the most recent investigators have exhibited a singular blindness to the labours of other men. In the history of science, this will not redound to the honour of those in every way eminent philosophers, who unfortunately have not been able to rise above the little jealousies of ordinary mortals.

To render the phenomena, and the hypothesis involved, intelligible to those who may not have studied the subject, it is necessary to recapitulate, and enter a little into detail.

The image produced by decomposing a white sunbeam consists of certain brilliantly-coloured rays, but those rays are crossed by spaces giving no Light. The dark lines are always found in the same places in the solar spectrum, but they vary in number under different aspects of the Sun and varying conditions of the Earth's atmosphere. When the Sun shines in its meridian splendour from a clear sky, the number of dark lines is slightly different from those observed when the Sun, being near the horizon, has to penetrate a greater depth of atmosphere. "It is," says Dr. Gladstone, "a most beautiful and striking sight to observe the gradual appearance of these characteristic lines as the Sun descends towards the horizon," proving that some of these non-luminous spaces are due to terrestrial atmospheric absorptions. To quote again the same authority, "That the Earth's atmosphere has much to do with the manifestations of those lines, is beyond all question, and the analogy" (alluding to some very striking experiments made by Dr. Miller) "of such gases as nitrous acid or bromine vapour, *suggests the idea that they may originate wholly in the air that encircles our globe.*"

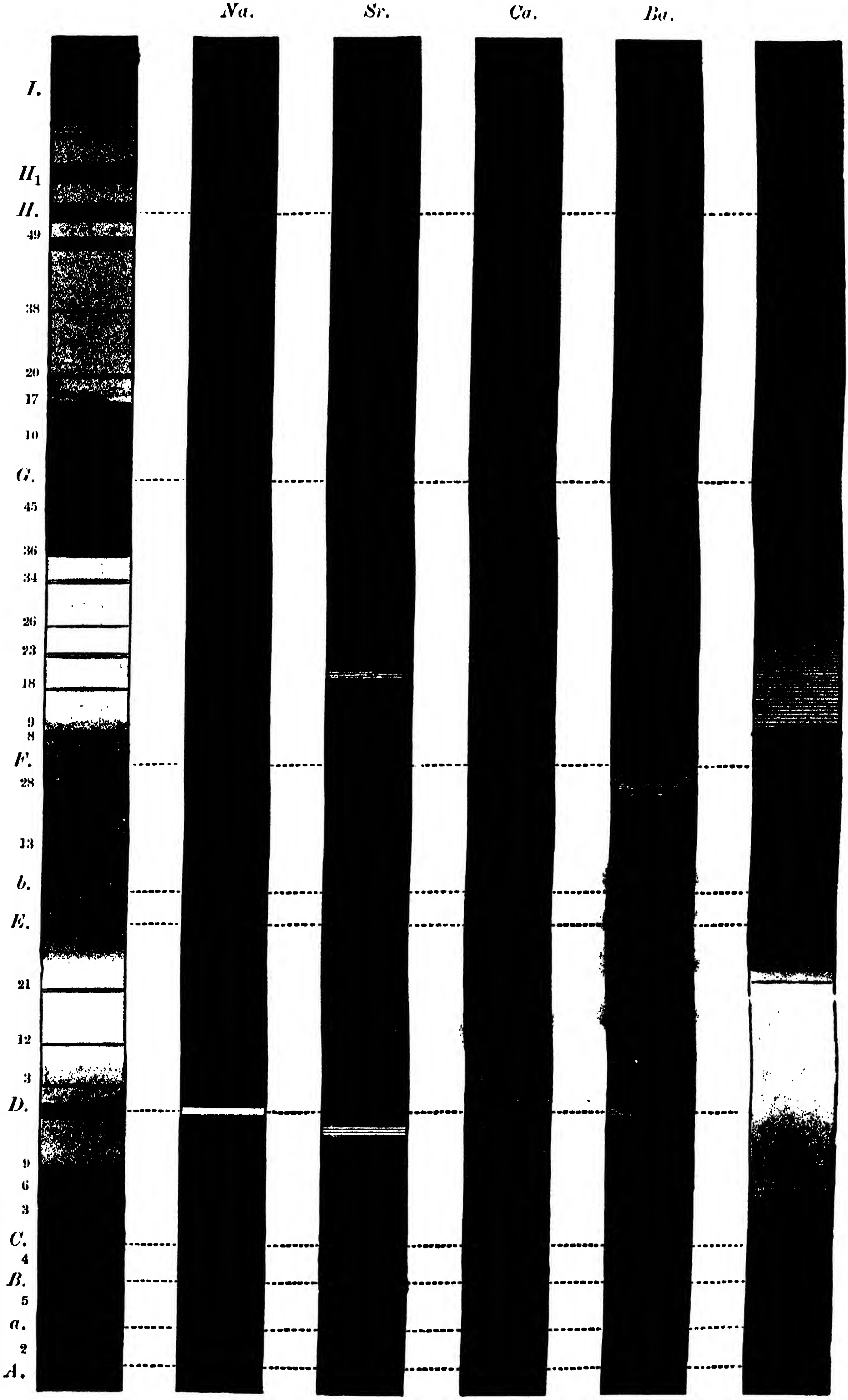
This suggestion is italicised for the purpose of giving our readers the full force of the evidence in favour of the views that the majority of those lines are of solar and not of terrestrial origin.

The spectra, obtained from some artificial sources of Light, exhibit the coloured rays shading one into the other; while those produced by some others, consist of a series of *luminous bands*, separated by dark spaces; and *these luminous bands are frequently* [illegible] *to coincide with the dark lines of the solar spectrum.*

Dr. W. [illegible]er observed, that an intense yellow ray observable in t[illegible]tra, obtained from the flames coloured with soda, lime[illegible]ia, baryta, zinc, iron, and platinum,—and, according [illegible]str[illegible] the electric light of *every metal burnt* by him,—had t[illegible]e refrangibility as the line D in the solar spectrum.

"But the most remarkable case occurs when carbon or sulphur is burnt in nitre. The brilliant Light, when analysed by a prism, exhibits a spectrum about as long as that of the sun at noon-day, but marked by *bright lines*, among which three are particularly prominent, respectively violet, yellow, and red in colour. The violet ray is not quite so refrangible as the solar H; but the yellow is coincident with D, and the red with A; while between the red and yellow appear at times fainter lines, one of which coincides with B, and a bundle sometimes appears in about the position of A."—(*Brewster and Gladstone.*)

Pyrotechnic displays will have made the least scientific of our


Na.
Sr.
Ca.
Ba.
I.
H_1
H.
49
38
20
17
10
G.
45
36
34
26
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18
9
8
F.
28
13
b.
E.
21
12
3
D.
9
6
3
C.
4
B.
5
a.
2
A.

readers acquainted with the fact, that we may, by burning certain mineral substances, produce very intensely coloured lights. Soda, or common culinary salt, gives a monochromatic yellow; strontian produces the red fires of our theatres; barytes, the pale green of ghost scenes: copper burns with a green flame; iron, with a yellow-brown one; and lithium with a brilliant crimson. Now, if these flames be examined through a prism, or if a concentrated pencil from those artificial sources of coloured light be passed through one, we obtain well-marked spectral images, some of which are represented on the accompanying drawing.

1 is the Solar spectrum, with its principal black lines, those marked with capitals being the more important.

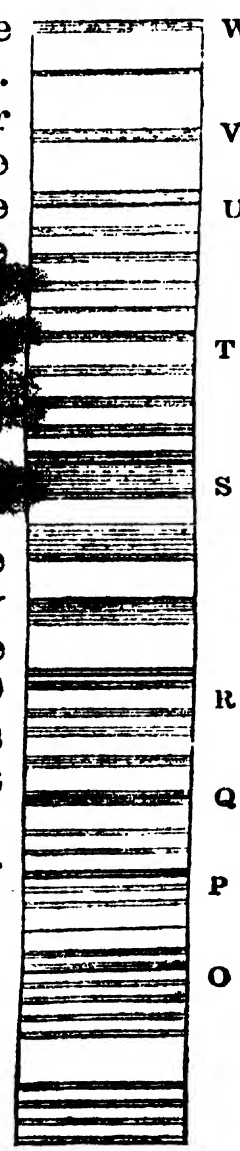
2. (*Na.*) The bright yellow line produced whenever soda, in any form, is present in the source of light.

3. (*Sr.*) The interesting series of bands produced by strontian.

4. (*Ca.*) The spectrum obtained when chloride of calcium, or any of the salts of lime, are subjected to combustion.

5. (*Ba.*) The spectrum produced by the barytes salts.

6. (*K.*) The spectrum observable when potassium or any of the salts of potash are vaporized in a flame.



The woodcut annexed, shows the extension of the solar spectrum to the end of the fluorescent rays. This is given to prove on the authority of Professor Stokes, that these most highly refracted rays have a larger number of *inactive* dark spaces than the more decidedly luminous rays possess. We have yet to examine, with the closest care, the relat[illegible] those lines to our own atmospheric influence[illegible] is necessary, therefore, to observe much caut[illegible] receiving the evidence which has been brough[illegible]ward in proof of the solar origin [illegible]se st[illegible] bands. But let us examine the p[illegible]

Kirchoff and Bunsen lay great stress upon the sodium spectrum, as proving the extreme delicacy of this mode of analysis. The yellow line—the only one seen—is coincident with the dark line D of Fraunhöfer. This beautiful bright yellow line is observable when less than $\frac{1}{20,000,000}$th of a part of soda smoke is mixed with air. From the circumstance of the air of these islands, having almost always some saline matter floating in it, the yellow line of the sodium spectrum is rarely absent. The lithium spectrum has not been represented on our plate; but it gives two sharply defined lines: one a bright red, the other a yellow one—the former apparently corresponding with line five between B

and C of Brewster's spectrum; it is not easy to determine accurately with which of the dark lines this yellow line is coincident.

Strontian gives six red, one orange, and one blue line. Calcium and its salts, a bright green line, an intensely bright orange line, and the paler intermediate bands. Barium gives well-defined green lines, some yellow lines, varying in intensity, an orange line, and indications of red.

Such are the general characteristics of the spectral images produced. Kirchoff and Bunsen say, in arguing upon these lines, and the hypothesis of their representing the solar dark lines: "It was proved from theoretical considerations, that the spectrum of an incandescent gas becomes *reversed* (that is, that the bright ones become changed into dark ones) when a source of light of sufficient intensity, giving a continuous spectrum, is placed behind the luminous gas. From this we may conclude that *the solar spectrum, with its dark lines, is nothing else than the reverse of the spectrum, which the sun's atmosphere alone would produce.* Hence in order to effect the chemical analysis of the solar atmosphere, all that we require is to discover those substances which, when brought into the flame, produce bright lines coinciding with the dark ones of the solar spectrum."

The coincidence of the soda line with dark line D is striking; one of the yellow lines produced by barium appears to correspond with it, and it must not be forgotten that Angstrom proved the yellow lines produced by other bodies to be coincident with D.* The red line of the potassium spectrum is coincident with the dark space A. The other lines are not so satisfactorily determined: where there are such a number of *dark lines*, there is no difficulty in assigning to one of the bright ones a place amongst them; but it requires the utmost care to determine the *exact* coincidence of a bright with a dark space.

The next step in the process of the investigation instructs us in the fact, that the vapours producing those coloured flames are opaque to their own rays. That is to say, if we produce a yellow soda-flame, and from it obtain a spectrum showing the peculiar soda lines in their bright yellow colour, and then impregnate the air with some soda vapour, by volatilizing soda between the flame and the spectrum, the *bright yellow line* becomes at once *a black*

* While those pages have been passing through the press, a communication has been made to the Parisian Journal (*The Cosmos*), by M. Morren, urging the necessity of caution in making deductions, because, as stated in this paper, the yellow line produced by Sodium is equally producible by other bodies. Professor Frankland and Dr. Tyndall, in the *Philosophical Magazine* for December, call attention to the influences of variation of temperature in altering the character of some of the lines.

line. This holds true for all the substances which have yet been examined. The coloured bright lines are converted into dark lines, if the rays from the coloured flames are made to permeate vapours of the same constitution as those which produced the particular spectrum under examination.

Incandescent gases and vapours give off Light of certain definite degree of refrangibility, or they furnish spectra consisting of certain fixed lines; and those incandescent gases or vapours absorb Light of the same degree of refrangibility as that which they emit. This is only the expression in relation to *Light* of the celebrated statement made in regard to *Sound*—*that a body absorbs all the oscillations which it can propagate.*

All the bright lines of the spectra produced by the vapours of known metals which have yet been examined appear to be represented by the dark lines of the solar spectrum. Angstrom says, "The analogy between the two spectra, the metal and the solar, may be more or less complete when we consider the details. When taken together, they produce the impression of one being the reverse of the other. I am therefore convinced that the cause of the lines of the solar spectrum involves that of the bright electric lines."

It is difficult, within a limited space, to express, in terms which shall be intelligible to those who have had no previous acquaintance with the subject, the evidences which support the views of Kirchoff as respects the Sun. If we have been successful in our description of the phenomena involved in the consideration of this subject, it will be understood that all the *bright lines* which are seen when we produce spectra from the coloured flames obtained by burning any of the metals, correspond with the *black lines* of the solar spectrum. That is to say, dark lines always existing in the solar spectral image correspond with every line produced by a spectrum obtained by burning Iron; and so with regard to the other metals which have been examined.

The conclusion, therefore, is that the radiations from the centre of our system,—the Sun,—producing the phenomena of *Light*, *Heat*, and *Actinism*,—are due to the combustion of metallic bodies such as we find on this Earth.

The mass of the sun is, according to this hypothesis, regarded as being intensely incandescent. Matter, in all respects, probably, similar to that with which we are acquainted, is undergoing combustion, and, of course, surrounding the sun with a vaporiform atmosphere, consisting of the emanations from the ignited nucleus. But for this atmosphere (or, to employ a better term, this *photosphere*), the solar spectrum would give a series of brilliantly-coloured *bright bands*. We have stated that vapours are opaque to their own class of rays;

therefore, since the rays produced by burning iron, or magnesium, or lithium, or other metals, are not transmitted through the vapours produced by the combustion of those metals, the solar spectrum gives us an extensive series of dark bands.

That *every* black line in the solar spectrum represents rays emitted from some metallic body in a state of combustion in the Sun, is exceedingly doubtful. It has been already shown that many of the dark lines are due to the want of absolute transparency in our own atmosphere. But that Kirchoff's view of the coincidence of the black lines of the solar spectrum with the bright lines of terrestrial flames is a fair deduction from his experimental observations, must be admitted.

At the same time as those inquiries by Kirchoff, Bunsen, and others, have been proceeding, investigations in another part have brought us corroborative evidence. The band of astronomical observers who went to Spain, to note with all accuracy the phenomena which might present themselves during the solar eclipse, bring us back evidence of tongues of flame, or clouds glowing with the reflected lights of an intense combustion, coming strongly into view, when the bright light was obscured by the moon's body. Professor Airy states it as his belief *that the sun is boiling up*, and that the prominences observed *were fumes given off*.*

The photographs of Mr. Warren De la Rue are invaluable as affording indisputable evidence of the existence of these "pillars of fire." Recently, that gentleman has brought his excellent appliances to bear on the unobscured Orb of Light, and his photographs confirm all the observations of Mr. Nasmyth. The Sun's disc is covered by masses of curiously shaped and ever-moving forms, called by their discoverer (Mr. Nasmyth) "Willow-leaves." The inference is, that these are tongues of flame ever bursting from this incomprehensible mass, and dispersing Light, and its attendant forces, to all the planets. We advance, by the aid of optical science, of chemical experiment, and astronomical observation, to the deductions:—That the Sun is constituted of matter similar to that which we find in this world: That this matter is ever burning; but, as Newton supposed, returning in a changed form into itself by the force of attraction in the mass: That the physical forces which are developed by those vast chemical changes are radiated in waves through space.

In conclusion, that man should, by the power of mind, be enabled to extend his investigations from the Earth to the Sun, and determine the chemical composition of a body, millions of

* Full details of this interesting phenomenon will be published in our next number, in an astronomical article, by Mr. James Breen, one of the observers referred to.—ED.

miles distant from him, is not a little remarkable, and proves the Divine origin of his intelligence; but, by his Philosophy, he has done yet more than this, in proving the completeness of the Balance of Forces throughout the universe. Vast chemical changes are taking place in the Sun, and, for every grain of matter altering its form, an equivalent of physical force is given out in a radiant state. These rays pass through space, and reach our Earth, and here they are employed in producing exact equivalents of vital and other phenomena.

The minutest terrestrial organism is the result of chemical changes taking place in the Sun. That stupendous orb is the great laboratory in which are generated those Powers by whose agencies all the planets of the system are regulated. In obedience to the Great Creator, who "caused the day spring to know his place,"—those mysterious agencies,—with the source of which man is now becoming acquainted,—are flooded out in profusion from the Sun, causing crude matter to pulsate into Life and Beauty upon every rolling orb within the solar realm.

THE OPTICAL PHENOMENA OF THE ATMOSPHERE.

BY G. F. CHAMBERS.

THOSE appearances in the heavens, such as the Rainbow, the Aurora, &c., which frequently present themselves to the gaze of man, although perhaps only for a brief space of time; and which, during that time surprise him by their brilliancy and beauty, were amongst the first external phenomena in nature that impressed themselves upon his dawning intelligence.

And yet, as we often find to be the case, those very commonplace phenomena, which have been witnessed from time immemorial, are less understood than are the less striking ones, which, from the rarity of their occurrence, rivet the attention and lead to various speculations as to their nature.

It is our intention in the present paper to say a few words concerning these ordinary optical phenomena.

The *Rainbow* is one of the prettiest, as it is also one of the commonest atmospheric appearances with which we are acquainted: it is never seen but in showery weather, when the Sun illuminates the falling rain, and the spectator turns his back to the Sun, whose elevation above the horizon must not exceed 42°.

The earliest historic mention of the Rainbow is in Genesis ix. 13, where it is mentioned in connection with a pledge from the Great Ruler of the Universe that this Earth should never again be overwhelmed with another general deluge.

Homer says—

> "Like unto rainbows, which the son of Saturn
> Hath fixed in a cloud, a sign to articulate speaking men."*

Virgil speaks of Venus as—

> "The Virgin goddess, seen by none, hastening her journey through
> A bow of a thousand colours, glides down with a nimble tread."†

Various speculations are to be found in the works of old

* *Iliad*, lib. xi, line 28. †*Æneid*, lib. v. line 609.

writers relative to the cause of the Rainbow; many of them seem to have had an idea, that the refraction of the Sun's rays had something to do with it, but in what manner they do not appear to have known.

There are frequently two bows seen—a primary and a secondary one: the former is by far the brightest, being formed by the rays of Light falling on the upper part of the drops of rain; for a ray of Light entering the upper part of a drop of rain will, by refraction, be thrown upon the inner part of the spherical surface of that drop, where, undergoing a second refraction, it will be sent towards the eye of the spectator; since the rays which fall upon the primary bow come to the eye after two refractions and one reflection, and the colours of this bow, reckoning *outwards*, are violet, indigo, blue, green, yellow, orange, and red. The secondary bow is formed by the rays of Light falling on the lower parts of the drops of rain: these rays, like the former, undergo two refractions; viz., when entering the drops of rain, and when emerging from them in passing to the eye; but they suffer two or more reflections in the interior surface of the drops: hence the colours of these rays are not so strong and well-defined as those in the primary bow, and appear in an inverted order: red first, then orange, &c. This may be experimentally shown in the following manner:—Take a glass globe, filled with water, place it in the sunshine, turn your back to the Sun and view the globe, at such a distance that the part of it farthest from the Sun may appear of a full red colour; then the rays which come from the globe will be found to make an angle of 42°, with the direct rays of the Sun: retain the eye in this position, and let another person gradually lower the globe; then the red, orange, yellow, &c. colours will appear in succession, as in the primary bow. Again, if the glass globe be elevated, so that the side *nearest* the Sun may appear red, then the rays which come from the globe will be found to make an angle of about 50° with the direct rays of the Sun: retain the eye in this position, and let another person gradually raise the globe; then the rays will successively change from red to orange, green, &c., as in the secondary bow.*

The breadth of a primary bow is about 1° 45′, and of a secondary one, 3° 10′. From theory we may be led to infer the existence of tertiary and quaternary bows, but owing to their position and faintness, they are usually invisible. In addition to the regular bows, supernumerary ones are occasionally seen, which depend for their development on certain peculiar conditions of the atmosphere. Lunar Rainbows may also be

* This illustration is, we believe, due to Keith.

seen under favourable circumstances, but they are somewhat rare.

Coronæ are meteors seen around the Moon and other heavenly bodies, and are of a whitish, nebulous character. Coronæ appear in cumuli clouds, are only visible when there is much moisture in the atmosphere, and generally foretell a change of weather. They are due to the diffraction of Light.

Halos are prismatic rings of variable but considerable diameter, seen around the Sun and Moon, with the red colour nearer the centre than the blue. Several very fine ones were seen in the month of January, 1860. They are caused by the refraction of Light; not unfrequently several rings may be seen concentric with one another. Humboldt describes a very fine lunar halo seen by him at Cumana.

Glorias or *Anthelia* are coloured circles surrounding the shadows of observers. M. Bougues mentions that when he, Don Antonia Ulloa, and his companions, were upon the summit of Mount Pichincha, one of the Andes chain, and the Sun just rising behind them, each saw his own shadow distinctly projected with a gloria surrounding the head. The anthelia consisted of three concentric circles of a lively colour and prismatic, the red being external.

Parhelia, or *Mock Suns*, are among the most beautiful of the meteors with which we are acquainted. They consist of halos and luminous arcs, intersecting one another in different directions and studded with solar images. These phenomena are also due to the action of atmospheric moisture on rays of Light, and are seen in the greatest perfection in the Polar regions.*

Paraselenæ, or *Mock Moons*, are not uncommon; they resemble in general character the preceding, and doubtless owe their origin to the same physical cause. Mr. E. J. Lowe, of the Beeston Observatory, thus describes a very remarkable halo with paraselenæ seen by him on November 12, 1859:—

"It consisted of a beautiful lunar corona, 10' in width, which exhibited faintly the prismatic colours. Also an ordinary bright halo, or circle of 22° 30′ radius, having the Moon for its centre; and a second very perfect circle, far too gigantic to allow of its being all seen at once, and therefore in the N.W. giving the appearance of an inverted rainbow. This circle had its centre 17° N.W. of the zenith, while its southern edge passed through the Moon. It was exactly 90° in diameter, yet gave the impression of being much larger. There were also seven mock moons. Two were situated at the intersections of the two circles; two others on the Moon's horizontal level and just without the circle of 22½° radius; the fifth and sixth on the great circle at a distance of 50° from the Moon on either

* See Parry: *Journ. of Voy.* 1819-20, pp. 156, 164, 172.

side; and the seventh on the same circle, a short distance without the smaller circle on the N. side. A lunar halo, and a small portion of the great circle, were seen for a short time by my assistant at 7 o'clock.

"This phenomenon was formed in cirri, and owed its disappearance to these clouds becoming cirrocumuli. The temperature was 32·2°, and the wet bulb thermometer 30·8°. The wind, a gentle breeze from E., the clouds floating in a S.W. current. At 12 30 a.m. (13th) the wind veered through N. to N.W."*

The Aurora Borealis is a luminous phenomenon seen in high latitudes in both hemispheres, and would with more propriety be termed the *Aurora Polaris*. It is, however, more commonly spoken of as the Aurora *Borealis*, or *Australis*, according to which hemisphere is referred to. The appearances presented, consist of streaks or rays of Light, of greater or less intensity, diverging in every direction from a central point, and which became visible in the northern horizon soon after sunset. Frequently a dull confused mass of Light, of a pinkish hue, appears, and it is from this that the phenomenon derives its name.†

The precise physical cause of the Aurora Borealis is not yet satisfactorily ascertained, but all the appearances connected with it are electrical; and its form, direction, and position, though ever varying, always bear a marked relation to the Magnetic meridian and poles. Whatever, therefore, be its physical nature, it is evident that the theatre of its action is the atmosphere, and that the agent to which the development is due is Electricity, associated, in some unascertained manner, with Terrestrial Magnetism. During the prevalence of Auroral displays, Magnetic needles are very generally subject to much disturbance—a fact first noticed by Halley. A copious deposition of dew, sudden thaws, and severe gales in the English channel, are also among the occurrences which seem to be connected with the appearance of this interesting phenomenon. Increased brilliancy in the light of the stars situated in the vicinity of the display has also been noticed. If the reader should be in possession of an electrical machine, he may obtain a very satisfactory representation of the Aurora by discharging an intermittent supply of electricity through a partially exhausted glass tube bent into the form of a semi-circle.

The Aurora Borealis seems subject to periodical visitations; sometimes it is seen very frequently, at other times years pass by without any apparitions being noticed. Thus we find that few were noted in the seventeenth century; at the beginning of the eighteenth, they recommenced, and lasted till about the middle of that century, when there was a partial cessation. During the last few years, as is well known, some splendid

* Letter in *The Times*, November 15, 1859.

† Aurora, the dawn.

displays have been witnessed, especially in 1859. Besides this secular variation, there seems to be also a mensual variation. The following table, derived from a large number of recorded displays, will illustrate this point:—

	PER CENT.
January	7·0
February	9·4
March	13·4
April	9·6
May	5·7
June	2·0
July	2·7
August	6·7
September	12·4
October	15·4
November	8·8
December	6·9
	100·0

Referring the above results to the four quarters of the year, we get the following table. The paucity of Auroræ during the summer months is doubtless partially to be ascribed to the shortness of the nights:—

	PER CENT.
Spring (March, April, May)	28·8
Summer (June, July, August)	11·4
Autumn (September, October, November)	36·5
Winter (December, January, February)	23·3
	100·0

There seems also to be a diurnal periodicity. Bravais remarks that auroral displays happen most frequently about 10 P.M., and rarely after 4 A.M.

Many observers have thought that they have heard sounds emitted by Auroræ. Possibly this is referred to by Virgil, who, after describing the prodigies at Cæsar's death, says:—

> "Armorum sonitum toto Germania cœlo
> Audiit."*

Much uncertainty exists on this point, as the evidence is very conflicting.

The influence of the Aurora in producing gales of wind seems to have been first pointed out by one John Winn, in a letter to Dr. Franklin, dated Spithead, August 12, 1772. He says:—

"I believe the observation is new that the Aurora Borealis is constantly succeeded by hard southerly or south-west winds,

* *Georgics*, lib. i. line 473.

attended with hazy weather and small rain: I think I am warranted, from experience, to say, constantly; for, in twenty-three instances that have occurred since I first made the observation, it has invariably obtained.

"Sailing down the English Channel, in 1769, a few days before the autumnal equinox, we had a remarkably bright and vivid Aurora the whole night. In-shore, the wind was fluctuating between N.N.W. and N.W.; and farther out, W.N.W. Desirous of benefiting by the land wind, and also of taking advantage of an earlier ebb tide, I dispensed with the good old marine adage, never to approach too near a weather-shore, lest it should prove a lee-shore; and by short tacks clung close along the English coast. Next day the wind veered to the S.W., and soon after S.S.W., and sometimes S. We were then in that dangerous bay between Portland and the Start Point, and carried a pressing sail, with hopes of reaching Torbay before dark; but night fell upon us with thick haze and small rain, insomuch that we could not have seen the land the distance of a ship's length. The gale now increased to a storm; nothing remained but to endeavour to keep off the shore till the wind should change. Luckily our ship was a stout one, and well rigged.

"Since I have made this observation, I have got out of the Channel, when other men as alert and in faster ships, but unapprised of this circumstance, have not only been driven back, but with difficulty escaped shipwreck."*

Colonel Capper remarks:—

"As it appears that on all such occasions the current of air comes in a direction diametrically opposite to that where the meteor appears, it seems probable that the Aurora Borealis is caused by the ascent of a considerable quantity of electric fluid in the superior regions of the atmosphere to the N. and N.E., where, consequently, it causes a body of air near the earth to ascend, when another current of air will rush from the opposite point to fill up the vacuum, and thus may produce the southerly gales which succeed to the Aurora Borealis, &c."

The earliest notice we possess of the Aurora is to be found in the writings of Aristotle. Other classical writers also allude to it. In 1574, in the reign of Queen Elizabeth, there was a fine display seen in this country, which Stow thus describes:—

"The fourtænth of Nouember being Sunday, about midnight following, diuers strange impressions of fire and smoake were seene in the ayre, to proceede foorth of a black cloude in the North towards the South, which so continued til the next morning that it was daylight. The next night following, the heauens from all parts did seeme to burne marueilous

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* *Phil. Trans.* vol. lxiv. p. 128. 1774.

ragingly, and ouer our heads the flames from the horizon round about rising did meete, and there double and rolle one in another, as if it had bene a cleare furnace."*

In 1575, the Aurora Borealis was seen in Holland, and Cornelius Gemma, of the University of Louvaine, says:—

"The form of the chasma of September 28 following, immediately after sunset, was, indeed, less dreadful, but still more confused and various [than a previous display which occurred in the same year], for in it was seen a great many bright arches, out of which gradually issued spears, cities, with towns and men in battle array; after that there were excursions of rays every way; waves of clouds, and battles mutually pursued and fled, and wheeling round in a surprising manner."

There is strong reason to believe that the Aurora has become much commoner in Europe than it formerly used to be, and has correspondingly diminished in the northern parts of Asia, as Von Wrangel was informed by the natives. The Shetlanders speak of the Aurora as the "Merry-dancers." The ancients, amongst other appellations, called it the "Capra Saltans" (Dancing Goat). The wild Indian savage views in it the spirits of his forefathers roaming through the realms above. "Flying dragons, hostile armies, and other signs and prodigies, have been traced by the superstitious in the *bloody rods* and burning spears of the Aurora, no difficulty being found in accommodating the modes of celestial warfare to the ideas of the beholders and the times."

* *Annals.* Fol. London, 1631.

MISCELLANEA.

THE PROGRESS OF SCIENCE SCHOOLS AND CLASSES; WITH HINTS FOR THEIR FORMATION.

BY THE EDITOR.

TWO incidents have occurred since the publication of our last number, which exhibit in striking contrast the present condition of the two greatest nations on the globe. One of these events was of vast importance; it took the world by surprise, and was as eagerly canvassed by men of every rank and nation, as though it had been a defeat or victory which decided the fate of some great empire. The other was but of little moment in the political world; it barely served to interest for the hour, even during the inactivity of a parliamentary recess, and the report of its occurrence hardly extended beyond the sea-girt shores of Britain.

The first was the presentation, by the French Minister of Finance, of that memorable balance-sheet which showed the nation that, in consequence of its excessive expenditure for military and naval purposes, it was in debt forty millions of pounds beyond its income; whilst the second was nothing more than the visit to Liverpool of the English Chancellor of the Exchequer, in company with his noble colleague at the head of the Educational Department of the State, to inaugurate a new School of Science,—a public intimation that, notwithstanding the calls which had been made upon the Treasury to enable the nation, if need be, to cope with a bellicose ally, the Chancellor had in his coffers enough and to spare; and could afford any reasonable sum that might be required for diffusing useful information amongst the people.

If these two incidents afford any political lessons, they must be left to the consideration of statesmen, our business being only with the scientific and educational bearing of the one last referred to; and with this it is our intention to deal in the present paper.

The more we consider that great movement, of which the mainspring is the Science and Art Department of the Committee of Council on Education, and which is so young that it has not yet received a name—that national movement in science,—the more completely are we convinced that it is one which will add greatly to the welfare and happiness of our fellow-countrymen, and that it will be the means of affording remunerative as well as elevating employment to men and women in every class of society.

Our last brief article on the subject called forth inquiries from which we feel assured that if the details of the scheme, nay, if its existence, were more generally known throughout the country, it would give an

impetus to the labours of teachers and students, such as the founders of the scheme never anticipated; for there are no limits to the good work that it might originate and accomplish.

Let it be our endeavour, then, to give to it that publicity which we consider so desirable, and to indicate the mode in which those who have not yet been made acquainted with its existence may participate in its advantages.

"The Department of Science and Art is now the constituted machinery for giving State aid to certain branches of instruction in Art, and in certain definite subjects of Science."*

These subjects are:—

I. Geometrical Drawing, &c.
II. Mechanical Physics.
III. Experimental Physics.
IV. Chemistry.
V. Geology, Mineralogy, &c.
VI. Zoology.
VII. Botany.
VIII. and IX. Navigation, Nautical Astronomy, Physical Geography;

and the State grants pecuniary aid to *teachers* who have passed an examination in these branches of Science at South Kensington, and have obtained a certificate of competency, as well as valuable and honourable prizes (elegantly bound books, medals, &c.), to successful *students*, in whatsoever manner they may have been educated,—that is to say, whether by certificated or uncertificated teachers, or by self-tuition. The aid to certificated teachers consists of "certificate allowances," and "payments on results," the first-named being a sum of money for each pupil taught (up to a certain number); and the second, a *further* sum for every pupil who obtains a prize, the amount being regulated by the nature of the prize, 1st, 2nd, or 3rd class, and limited only by the teaching capabilities of the master, and the numbers and industry of the students.†

The prizes of the last-named, known as "Queen's Prizes," consist of the scientific works of Owen, Faraday, Lyell, Tyndall, Carpenter, &c., or the more popular ones of Gosse, Darwin, Rymer Jones, Lardner, and others; and besides these they may, by greater assiduity, obtain "Queen's Medals," of gold, silver, or bronze.

We cannot enter further into details, and must conclude this portion of our subject by stating that the examination of *teachers* takes place annually at the South Kensington Museum, London, about the middle of November, the State defraying the travelling expenses (including cost of living in

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* This extract is from a lecture delivered at the South Kensington Museum, February 4, 1861, by Captain Donelly, R.E., Inspector of Science, "On the Promotion of Science Instruction, by the Department of Science and Art."—It may be obtained by applying to Henry Cole, Esq., C.B., Secretary of the Science and Art Department, South Kensington.—Price 2*d.*

† As regards the income to be derived by teachers from Government grants, we believe that it ranges from £20 to £100.

London) of candidates; and the examination of students is held in the month of May in the locality in which the school or class may be established. There also *self-taught students,* or such as have been taught by uncertificated teachers, have the same privilege of competing for prizes as students educated in the Science school.*

Let us now glance cursorily at a few of the results of this assistance granted by the State towards promoting instruction in Science.

Last March there existed thirty schools and classes in England and Scotland,† and others have since been started, or are in process of formation. There were 111 certificated teachers in Great Britain; and besides these, many tutors not holding Government certificates prepared their pupils for the Science Examinations; several students, too, were successful in obtaining prizes at the May Examinations whose scientific knowledge was the result of home-culture, without any artificial tuition.

It will be very encouraging to young persons of both sexes, who may be actuated by the laudable desire to secure honourable rewards as the result of useful employment of their leisure time, to know that these "self-taught" students have been amongst the most successful in obtaining prizes; Mr. F. W. Rudler, of London, for example, having carried off the gold medal, and Mr. George Tindall, of Huddersfield, one of the silver medals for physiology at the examination last May.

The list of prize-holders also includes many of the fair sex, but so far we do not find one female teacher. One of the probable causes of this circumstance (to which we referred in our last), is the absence of any reference to female teachers in the "Directory," in which the male pronoun is invariably employed in speaking of the teachers; but a still more important one will be found in the difficulties that are presented to young persons of the other sex who may desire to attend the examination in the metropolis—we refer to the hesitation which must necessarily be felt by young girls to travel alone, *second-class,*‡ in winter, and stay without protection in London during the examination. Perhaps those who have wisely projected the scheme may deem this matter worthy of their consideration, and may provide a safe asylum for such female candidates as desire to avail themselves of the advantages offered by the State. It is a subject which must recommend itself warmly to all who take an interest in the employment of women; and if means could be devised to admit these to the privileges of teachers, the number of *students* of the same sex would also be materially increased.

Amongst the various schools that have been established, we know of none that has been more successful, under unfavourable circumstances, than the one at Banbury. It was opened early in the present year, there

* For detailed information on this subject, we refer our readers to the "Directory" of the Science and Art Department, South Kensington, which may be obtained (price 6*d.*) by applying, or writing, to the Secretary of the Department, Henry Cole, Esq., C.B.

† We have no doubt that the time is not far distant when there will be this number in such places as Liverpool, Manchester, &c., to say nothing of the metropolis, in which seven are already established.

‡ The State only allows the second-class fare.

not being a certificated teacher resident in the town at the time, and we perceive by a report lately issued, that, at the examination held in the school last June, thirty-three out of thirty-eight students passed in physiology: of these twenty-eight obtained "Queen's Prizes" (including James Smart and Charles Taylor, to whom bronze medals were awarded); and out of twenty-four students in zoology, eleven passed the examination, and three secured prizes.

All these young men owe their success and improved culture to the philanthropic exertions of Mr. J. H. Beale, a member of the committee of the school, who undertook the task of instructing them without any prospect of pecuniary remuneration; and also to the zeal and energy of Mr. James Cadbury, the secretary, and one of the originators of the school.

A second branch of Science has been added,—a class in chemistry being now gratuitously and worthily conducted by Mr. J. H. Beesley,* an analytical chemist in the town, who has placed his laboratory at the disposal of the students for the purpose.

In connection with the Banbury Institution we must not omit the mention of Dr. Acland, of Oxford, who has taken a deep interest in its formation and in the movement generally.

Another thriving little institution is the Science School at Wigan, where classes are established under the direction of Mr. E. H. Birkenhead as teacher. This gentleman held, before November last, no less than *seven* Government certificates of the first-class, in physics, geology, &c., and two of the second-class in chemistry, &c.† Our readers will not be surprised to hear that the pupils of so proficient a teacher were *all* successful at the last examination, none having entirely failed, eighteen having obtained "Queen's Prizes," and two, silver medals. Mr. Birkenhead is now also installed as Lecturer on Geology at the Liverpool School of Science. At Wigan, the institution owes its prosperity in a great measure to the active zeal of the Rev. T. F. Fergie, the incumbent of Ince, near that town.

At Liverpool, a school has been established, as already stated, under the most favourable auspices, and we have very good grounds for expecting that it will prove a successful and thriving institution. The active support and sympathy of the Lord President of the Council, the head of the Educational Department of the State, seconded by the eloquence of the Chancellor of the Exchequer, and of other eminent men, could not fail to impress all classes of persons with the importance of the movement, and to enlist their warmest sympathies; whilst the munificence of such men as Mr. William Brown, Mr. Graves the late Mayor, the President of the British Association, and other gentlemen resident in the town and neighbourhood, has rendered permanent that which might, without such aid, have been but a temporary boon to the important town of Liverpool. The school commenced its operations early in December, with about 140 students (including many pupil-teachers who have free admission to the

* Since this article was written, Mr. Beesley has taken a first-grade certificate.

† He now holds nine first and two second-class certificates.

lectures), besides about twice that number of persons of both sexes, and drawn from every grade of society, who had become subscribers, either annual or to the course on geology, and who are regular attendants at the lectures. There are now in this school, class-lectures delivered on geology, mineralogy, zoology, and botany.

It must not be supposed that the selection of these few eminently successful institutions has been an invidious one; for although we have chosen those with the operation of which we are the best acquainted, to illustrate the progress of the movement, we believe that nearly every class which has been established has been attended with a success more or less marked; and we shall now conclude these observations with a few hints to those who are able and willing to lend their co-operation in the good cause.

First, then, we may mention, that the State requires that a proper room, with firing and lighting, be provided for the reception of the class to be established, and that a Committee be formed for the purpose of taking charge of the diagrams and apparatus, of which Government defrays half the cost. It is hardly necessary to suggest that the best course which can be adopted with regard to the first-named stipulation, is that the "Science School" or class should be established in connection with some already existing institution, such as a Mechanics' Institute, Literary, or Mutual Improvement Society, or Public School. With respect to the Committee, it will be found that the State requires at least five members, one of whom must be the Mayor, Alderman, or a Member of the Town Council, or a person who is at the head of a Grammar School or other Public School. This is easily managed, for the difficulty is not to find men of position who will lend their *names*, but such persons as will give their *time* for the work.

If the movement originates with a teacher who desires to start a class, the duties of the Committee are nominal, as they merely act as a medium by which the State can recognize and reward his labours; but in large towns, where there are to be several teachers or lecturers paid by a Committee of Management, the originators must proceed precisely as though they were establishing a Mechanics' Institution, first raising a small fund to defray preliminary expenses, and then seeking the co-operation of gentlemen to act as teachers (certificated or otherwise) in the school. The Mayor (for the time being) should be induced, if possible, to act as the nominal president, and a connection formed with the Town Council (a precaution necessary to prevent the institution from degenerating into a political or sectarian establishment), so that the school may be a recognized medium of instruction for all classes and denominations.

We believe that when such measures are taken it will be found that the school will be maintained, to some extent, by the donations and subscriptions of persons who will be merely honorary members, and it will then be for the Committee to secure the attendance of the industrial classes by admitting them at the lowest possible charge. Pupil-teachers in schools under inspection should be admitted free (for it must not be forgotten that it is for the education of those who are unable to pay for tuition, that the *State* affords its aid), and teachers in schools, as well as the "industrial classes" should be admitted at a low charge,—*not* gratuitously, or they will not value the instruction.

The great object to be kept in view in a large school, should be to train teachers who will subsequently establish classes in various parts of the town; and it is highly desirable that the institution should be in close proximity to a museum and library, so that the students may there find illustrative specimens of the various objects upon which lectures are delivered in the school, and works of reference to be consulted as the occasion requires. Under all circumstances, we believe that the State adapts its mode of extending aid to the wants, and as much as possible to the desires, of the district in which the effort is being made, and it is always glad to send a delegate from London to aid the projectors with advice and information.

Up to the present time classes have been established, chiefly in small towns; whilst they exist in such places as Dedham, Slaithwaite, Slough, and Accrington, and there are schools in towns like Banbury and Wigan, we do not even find *classes* in such places as Leeds and Hull, where the means of imparting instruction would be so easily procurable, and in Manchester and Birmingham the commencement has only just been made by enterprising individual teachers; but there are as yet no recognized public schools.*

We would finally draw public attention to the fact that this movement is especially deserving of the encouragement of the *middle classes;* for whilst its ostensible and, to a great extent, its real object is to elevate the intellectual condition of the masses, it is opening out to the poorer but more intelligent members of the middle classes such a field as has never yet been presented for honourable, intellectual, and at the same time remunerative employment.†

Many a poor, hard-working professional man, or clerk, will have an opportunity of adding to his limited income by establishing a Science Class, and that too without interfering with his ordinary avocations; and, by the same means, many a respectable and intelligent girl may be saved from misery and starvation!

We hope the good work will prosper, and shall be happy at all times to lend it our hearty co-operation.

* A communication received from Wm. Fairbairn, Esq., of Manchester, leads us to expect that a school will shortly be established there; and when we mention that the President of the British Association is likely to be the prime mover, it is needless to add that, if undertaken, the enterprise will be sure of success.

† To show that this statement is founded on fact, we may mention, that when an assistant secretary was required for the Liverpool School of Science, whose duties necessitated his attendance two evenings weekly, the salary offered being £20, there were about 400 applicants for the post. Many were schoolmasters, teachers, and gentlemen established in some honourable profession, who were desirous of increasing their incomes.

If those persons had been proficient in any one branch of science, they might have earned four or five times the amount offered, by successful tuition.

Provincial Institutions and Societies.

The large amount of space which we have deemed it necessary to appropriate to the important subject of Science Schools, allows us to do little more than to acknowledge the following Reports, &c. :—

The Wigan Mechanics' Institution comprises a library, newsroom, evening classes, mining and mechanical (science) school, gymnasium, singing class, "Society of Arts" class, public readings and lectures, excursions, a chess-club, and a penny savings'-bank. It has been in existence seven years, and is supported by the leading gentlemen in Wigan and the neighbourhood.

The Liverpool Chemists' Association, intended chiefly for the improvement of young chemists and druggists' apprentices. It commenced its operations in 1854 with 73 members and associates, and now numbers upwards of 186 members.

The lectures are all of the most interesting and practical nature, and the library contains the most important recent scientific works.

Southampton Microscopical Society. The President of this institution, Dr. J. Bullar, says :—

"The social aspect of our society commends it. It is a pleasant way of spending an evening where there is a scientific object of natural interest, and, at the same time, a social gathering of many having the same tastes and objects, and, therefore, the same sympathies. The anatomy of an insect, too, is a more harmless occupation than the minute dissection of a neighbour's natural history. Tea and coffee, pleasant chat with those of like tastes, and then the table covered with microscopes and the specimens explained by one and passed round for each to examine, calling out animated talk on subjects worth discussing, or a short paper read and discussed on the subject illustrated, are civilizing. For science is a civilizer. It refines the tastes and elevates the thoughts, as it is the search after truth for truth's own sake. And in this age, when the progress of the nation and of the world is estimated by the money-value of exports and imports (and in this aspect the world's progress is prodigious and annually increasing), the danger must lie in estimating all things in reference to money rather than to truth. Now, science is a counteracting force. It neither brings wealth to its true cultivators, nor can wealth buy scientific tastes or scientific fame. It belongs to a higher region than 'the diggings.' It must breathe 'a purer ether, a diviner air.' And those who are engrossed in commerce would often do well, for their own content and happiness, by seeking in the recreations of science a complete change of action, thought, and feeling. Obviously the eye service which the microscope requires, trains the eye to minute and discriminative observation, and the hand to delicate accuracy. It leads on, if used scientifically, to the improvement of the scientific powers. The memory, the investigation of causes, the estimation of evidence, the power of distinguishing and of generalizing may be called into activity. But the mind has other and deeper needs than these. The senses lead to the awakening and culture of deeper powers inherent in the soul itself, and the microscope may excite and cultivate, not only the sense of the true, but of the beautiful. Constable, the landscape-painter, said that, pictorially, nothing in nature was ugly ; and surely we may say the same microscopically. The higher the magnifying powers, the more minutely extensive the investigations, the more beauty do we see. Even in the unhealthy secretions,—in what look to the unscientific eye like repulsive

fluids, in the very disorganizations which slowly ruin this goodly human frame, the microscope discovers forms of the highest geometrical accuracy, as well as of the most delicate beauty. And this beauty and consummate finish are everywhere, and are found farther and deeper as our powers increase of observing them. Here, too, at every step we find the limitation of our own powers, and the illimitable field of nature; the infinite contrasting with our finite, teaching us 'the moral lesson of science,—humility.'"

Manchester Literary and Philosophical Society, Microscopical Section.—With the permission of the author, we reprint the following paper "On Preparing and Mounting Insects," by Mr. Hepworth:—

"I herewith send you a specimen, for the inspection of the Microscopical section of the Literary and Philosophical Society, regretting I have not a duplicate to present to the members. Having seen and purchased some whole insects mounted by some gentleman (unknown to me) so beautifully, it caused me to make a series of experiments, which have resulted in producing the specimen before you. Although I have mounted great numbers, our unknown friend still bears the palm. The plan I have adopted, and which has been as yet the most successful, is the following: After destroying the insects in sulphuric ether (methylated being cheaper), wash them thoroughly in a wide-necked bottle (half-filled) with two or three waters; the delicate ones require great care. Then immerse them in liquid potash (or Brandishe's solution, which is stronger than the usual preparation), and let them remain a longer or shorter time, according to their texture. When ready to remove, put them one by one into a small saucer of clear water, and with a camel-hair pencil in each hand press them flat to the bottom, holding the head and thorax with the left-hand brush, and apply pressure with the other from above, downwards, giving the brush a rolling motion, which generally expels the contents of the abdomen dissolved by the potash. If you stroke the parts you are apt to separate the abdomen from the thorax. A minute roller of pith or cork might be used instead of the brush. In larger objects, use the end of the finger to flatten them. Large objects require more frequent washings, as it is desirable to remove the potash thoroughly, or crystals are apt to form after mounting. Having placed them on the slides with thin glass covers, tied down with thread, dry and immerse them in rectified spirit of turpentine; place the vessel under the receiver of an air-pump, and keep it exhausted until the turpentine has taken the place of the air bubbles: they are then ready for the application of the balsam. Larger objects may often, with advantage, be transferred to a clean slide; as, during the drying, there is considerable contraction, and an outline often remains beyond the margin showing this. When closely corked they may remain in the spirit for two or three months. As you take them from the bottle, wipe as much turpentine off as possible before removing the thread; and when untied, carefully wipe again, placing the finger on one end of the cover whilst you wipe the other, and *vice versâ*. By this means you remove as much turpentine from under the cover as is necessary; then drop the balsam, thinned with chloroform, upon the slide, letting the fluid touch the cover, when it will be taken in between the surfaces by capillary attraction; and after pressing the cover down it may be left to dry, or you may hold the slide over a spirit-lamp for a few seconds before pressing down the cover. If heat is not applied they are much longer in drying, but are more transparent. If made too hot the boiling disarranges the objects, and if carried too far will leave only the resin of the balsam, rendering it so brittle that the cover is apt to fly off by a fall, or any jar producing sufficient percussion. Never lift the cover up if possible during the operation, as there is danger of admitting air. A

few bubbles may appear immediately after mounting, but generally subside after a few hours, being only the chloroform or turpentine in a state of vapour, which becomes condensed."

Mr. J. B. DANCER read a very interesting paper "On Cleaning and Preparing Diatoms, &c., obtained from Soundings on the 19th November, 1860;" and Mr. G. MOSLEY one on the same subject, January 21, 1861.

Report of the Radcliffe Trustees on the Transfer of the Radcliffe Library to the Oxford University Museum, by Dr. H. W. ACLAND, Regius Professor of Medicine, Oxford; also, by the same author:—

Remarks on the Oxford Museum, containing an excellent plan of the new building, &c. &c.

At the *Liverpool Naturalists' Field Club* ten prizes were distributed at the meeting held for the purpose last October. Amongst the prizeholders, Miss Gibson collected and classified the largest number of species of plants during the season, namely 124, and received as prizes "Babington's Botany," and "Hibberd's Aquarium." The number of species collected and arranged by some of those ladies who were precluded from competing (in consequence of their having already received prizes), amounted to nearly 200. The society continues to flourish.

REVIEWS.

THE UNITY OF THE HUMAN SPECIES.*

HOWEVER M. de Quatrefages' book may have been received in France, we may venture to predict for it a remarkable degree of success if it should be translated and published in the English language.

Espousing, as he does, the popular doctrine of the origin of the human race, his evidence in its favour, which is based solely upon a consideration of the question from a scientific point of view, will be welcomed by all who are indisposed to deviate from the beaten path of tradition; whilst the most enterprising and latitudinarian inquirers, who hold contrary views to those adopted by the author, will be pleased to find themselves treated with respect, and their tenets combated with good temper and moderation.

The work will be read with additional interest in England, in consequence of the practical application which the author has made of some of the theories of Mr. Darwin, who will no doubt be astonished to see himself appear therein as the advocate of the "unity of the human species," and of the "immutability of species" in general.

So far as our limited space will allow, we shall endeavour to present to our readers a sketch of the contents; and they will then be in a position to judge of the correctness or otherwise of our statements.

As already observed, in advocating the "unity of the human species," the author leaves entirely out of account all theological and moral considerations, and throws himself completely upon the resources of science, of botany and zoology, physiology, medical statistics, ethnology, and the distribution of animals over the globe.

Often, he tells us, he had been tempted involuntarily to introduce evidence of a theological and moral character, but he always erased the words and fell back upon his scientific resources; his reason being, that inasmuch as he treats of a subject which more than any other belongs to the domains of the natural sciences, he wishes "to remain exclusively a naturalist, that he may preserve his right to address *all* men, and in order that he may lead the partisans of the most widely opposed doctrines upon neutral ground, on which no one, whatever may be his creed or instincts, has a right at this day to refuse to enter, and where all comers must indubitably be of one and the same mind."

Passing rapidly in review the different realms of nature, both inorganic and organic, the author leads his readers to the consideration of what he terms "The Human Kingdom."

* "Unité de l'Espèce Humaine." A. de Quatrefages. Hachette, Paris.

"By turns," he says, "man has been made to constitute a special *kingdom*, a *branch* of the animal kingdom, a *class*, an *order*, a *sub-order*, a *family*, a *sub-family*, a *genus*, a simple *species* of an order in which he has found himself closely linked together with the apes!

"It is not for me to discuss all these opinions, some of them of so strange a character; it will suffice that I should justify the one which I have held for many years, and which day by day I am more disposed to regard as the only true one.

"In my estimation man has as fair a title to be classed distinctly from the animal kingdom as the latter may be said to differ from the vegetable kingdom. He alone should constitute a separate realm, the *human kingdom*,* which is characterized by distinctive features of the same order as those which separate from one another the primordial groups that I have just enumerated."

The title of man to a separate kingdom in nature is found not in his anatomy, nor yet in the mode in which he exercises his animal functions; not in the possession of a voice, nor even in those emotions which are manifested so strongly in the human race. All these the author is willing to concede in a greater or less degree to the higher animals with whom man holds them in common. The attributes that entitle him to the distinction accorded to him are (as the reader will doubtless anticipate) his sense of right and wrong, his consciousness of the existence of the Deity, and his hope of immortality.

As there are, however, many authors who have denied to some of the most degraded races of men the possession of any of these attributes, the narratives of Dr. Livingstone and of other travellers are quoted to prove that even the most barbarous tribes possess at least the germs of these faculties; for even the idol-worship of the most debased Polynesians affords to the author sufficient evidence of the existence of religion in their minds.

He thus concludes his review of this portion of the subject:—"In order to follow Linnæus step by step in the definition of the nature of man, his characteristics, as he would be *zoologically* † designated, are—*Man is a body, or rather an organized being, living, feeling, moving spontaneously, and endowed with morality and religion.*"

Having thus sought generally to establish for mankind the major position of being so far superior to the animal races as to occupy a separate realm in nature, the author now descends to the consideration of "species," with a view to show that there are no specific differences between the *varieties*, as he considers them, of the human race.

He regards species as the "*unity*" of which all other subdivisions of the animal kingdom are composed (genera, families, orders, &c.), but "species" is itself divisible into *fractions*, called *varieties*.

Now, the question at issue between the advocates of that theory, which includes all the peoples of the earth in one species ("monogenistes"), and those who believe them to consist of more than one ("polygenistes"), is, whether the distinctions which characterize certain human groups are such as to constitute each a distinct species or "unity," or whether they amount only to a variety or "fraction."

This being the case, it is of primary importance that our readers should

* "Le règne homminal, ou règne humain."

† We beg the reader to remember this expression, as we shall revert to it in our criticisms.

form a correct estimate of the term "species," which is indeed the pivot whereon the whole argument turns; and as M. de Quatrefages passes in review the various definitions that have been applied to it by the most eminent writers on the subject, we shall extract the most important of these, representing the opinions of different naturalists. The definition of the term has been based upon two distinct phenomena, namely, the *resemblance* between individuals and their *descent* from similar individuals, or, as the author has it, "resemblance" and "filiation."

To place the inquiry in a clear and comprehensible manner before our readers, we will state it thus:—If there were placed before us two plants or animals closely resembling one another, and we were asked to decide whether or not they belong to the same species, would it suffice if we compare them with other animals; and finding that they resemble one another more closely than they resemble any others, we give it as our decision that they belong to the same species? Or is it necessary that we should first inquire into their parentage, in order to ascertain whether or not they were descended from the same original couple; and if they were not so descended, must we then decide that, however closely they may resemble one another, they are not of the same species? Or if they were, and yet were ever so *dissimilar*, must we pronounce them to belong to the same species?

The various replies that have been given to these questions may be found in the following opinions quoted by M. de Quatrefages as to what constitutes a species:—

RAY.—Vegetables which have a *common origin*, and are produced from seeds, whatever may be their apparent differences.

TOURNEFORT.—An assemblage of plants which are distinguished by some particular characteristic.

BUFFON.—Species is nothing else than a constant succession of similar individuals which reproduce themselves.

DE CANDOLLE.—An assemblage of all those individuals *which resemble one another more than they do any others; are able by reciprocal fecundation to produce fertile individuals, doing so by the generative process, and in such a manner that by analogy they may be supposed all to have been descended from one single individual.*

VOGT.—The reunion of all individuals which originate from the same parents, and are either themselves similar to the original stock, or became so through their descendants.*

LAMARCK only regards "species" as a relative expression, and for him it has no fixed existence. He believes in the transmutation from one species to another, and in the formation of new species, "through a tendency," says M. de Quatrefages, "to satisfy certain wants," and through the results of certain spontaneous acts of the individual.

* M. Vogt here refers to the recently discovered phenomena of "alternation of generations," which may be briefly and popularly described as follows:—From a pair of individuals proceeds an offspring so different to the parents, that it appears to belong to a different order. These young ones are usually barren in the ordinary sense; but by means of offsets, or some abnormal process, they produce a generation of individuals which are again fertile, and exactly resemble their "grandparents," if they may be so termed.

Finally—After considering to what degree of variation individuals of the same species are liable, M. de Quatrefages himself thus explains the meaning of the term :—" *Species is an assemblage of individuals more or less resembling one another, which are descended, or may be regarded as being descended, from a single primitive pair, by an uninterrupted succession of families.*"

Having thus defined the meaning of the term, the author next brings forward his evidence to prove that species is *immutable;* that is to say, that it never has varied since the commencement, and that there can be no transition from one species to another.

He adduces numerous examples in nature in support of this opinion, stating that there are trees in existence which must be thousands of years old, and which are still precisely similar to individuals of the same species, of recent growth.

Amongst others, he refers to a yew-tree 3,000 years old, and a Boabab-tree which is estimated at 5,000 years.

Another interesting example is found in the discovery of loaves of bread in the catacombs of Egypt, containing parts of the wheat-plant, which on examination proved to be precisely the same as that now cultivated.

Nor is the author arrested by the limits of the historic period, for, on the authority and experience of Michelet, he mentions the fact that near Dôle the seeds of a plant, *Galium Anglicum,* which had been found in the Diluvial deposit, had preserved their vitality so far as to germinate, and that they had produced plants precisely the same as the existing species. Some of the fossil remains of Mammalia, too, that are found in bone-caverns show that the animals exactly resembled species now to be found on the surface of the globe. From all these facts, the author concludes that species is immutable, and not subject to variation in time.

From the consideration of " species," he now proceeds to characterize " varieties " and " races " which represent, as it were, the amount of variation of which the first-named (*i. e.* species) is susceptible.

We cannot follow him through his discourse, but must be satisfied to extract his definition of " *variety* " as " *an individual, or an assemblage of individuals, belonging to the same sexual generation, but distinguished from the other representatives of the same species by one or more exceptional characteristics,*" and that of "*race*" as " *the assemblage of individuals belonging to one and the same species, having received and transmitted by means of generation the characters of a primitive variety.*"

In other words, according to M. de Quatrefages, a *variety* is characterized by a deviation from the original species, and a *race* is a variety which has multiplied and become permanent—a *perpetuated variety* in fact.

These varieties or races are of three kinds: first, those which have acquired certain peculiarities through the influences brought to bear upon them by nature only, without the intervention of man; secondly, cultivated varieties, in which man has been the modifying agent; and, thirdly, those varieties which, having been subjected for a time to the influence of the human race, have escaped and relapsed, as it were, into their natural condition. As the individuals which were originally tamed or cultivated had disappeared, the emancipated varieties thus became the representatives of a new race.

All these agencies, however, the author has grouped together under the title of " *milieu*" or "medium" (meaning thereby the "condition of existence"

a term embracing "every influence, whether physical, intellectual, or moral." The "medium,"* he goes on to say, renders the existence of varieties absolutely necessary; for if species did not yield to external circumstances—that is to say, if individual forms were unable to bend to external circumstances by which they are surrounded, to such an extent as to form *varieties*—they would die out, and the "species would cease to exist."

So great is the influence of the "medium," that it gives rise to varieties sufficiently marked to cause them to be mistaken for different species.

M. Decaisne, who is attached to the Museum of the "Jardin des Plantes" (where the author also fills a professorial chair), obtained from the country, seeds of a well-marked species of plantain, and sowed them in the garden of the Museum. They produced seven forms of the plant, each of which had up to that time been regarded as a distinct species. These did not differ on trifling points alone, but in the form and covering of the leaves, the roots, &c.; indeed, so great were the distinctions between them, that he considered the error of Linnæus and his successors quite pardonable when he classed them as separate species. Allowed to remain in the same "medium" (in this case, the same soil, temperature, &c.), these varieties became permanent; transplanted elsewhere, their characteristic features disappeared; and they came to resemble one another so closely that it was easy to distinguish them as merely varieties of the same species.†

But the author is not content to draw his examples from the vegetable kingdom; and where does the reader suppose that he finds his most convincing evidence in favour of the unity and immutability of species?

In the experience of Charles Darwin; and it is extracted from the very work, in which that author seeks to show the probability of the transmutation of species.

Here are the words themselves:—

"Mr. Darwin has gone still further. Led by his general studies to occupy himself specially with the problem of pigeons, he determined to probe it to the bottom. He surrounded himself with all the documents collected before his time; procured all the European races, and those of the English Colonies, entered into communication with the chief pigeon-fanciers in London, joined two special clubs, and himself tried numerous experiments."

"It was only by seeking to attain the truth by every possible means that he felt himself warranted in arriving at a conclusion; and his conclusion is most affirmative, in favour of the unity of species. He considers the Rock-pigeon (*Columba livia*) as the original stock from which all domestic pigeons are derived." . . . . "Finally" (says M. de Quatrefages) "the author sees a proof of the unity of origin in all the races of pigeons, in this fact, that the most dissimilar may be crossed and produce mongrels that are indefinitely fruitful. This is, indeed, a full and entire confirmation of the preceding conclusion, as the reader will understand later on."‡

* The reader will understand that when we employ this term after the author, it bears the construction of "influences or conditions of existence."

† A still more striking example of the power of man to modify species or varieties is to be found in the experiments of our esteemed contributor Professor Buckman upon the wheat-plant, as described in our first number, article "Corn."

‡ We are intentionally literal in our translation of these passages, as we desire to keep as close as possible to the original language of M. de Quatrefages.

The author subsequently reverts to Mr. Darwin and his theory; and we shall not fail to give the reader an opportunity of participating in the interesting association.

Having enunciated the principle that varieties present gradations as they recede from the specific type, or that a "species" is composed of different varieties blending into one another, the author now proceeds to apply this principle to the human race.

He shows that the most dissimilar types of mankind are brought into relationship by intermediate varieties, just as in the case of the pigeon; that on the continent of Africa, where we find the pure negro race on the one hand, and the white on the other, there are also intermediate tribes which present the distinctive features of both, and which form a connecting link between them.

That these two types (the black and white) only constitute *varieties*, the author finds in every way probable, not only in consequence of the presence of intervening groups, which form a transition from one to the other, but because intermarriages of these races are frequent and fertile—a phase of the subject which he treats more fully in a subsequent part of his work.

He next examines the nature and extent of the variations presented by the vegetable and animal *races*, as well as by man; showing, first, that the two former are characterized by *great* anatomical and physiological (and in animals psychological or mental) differences; and then that *races* of men also exhibit similar differences, but that the *extent* of such differences is much greater in animals which are acknowledged as *varieties* only, than in any known races of man.

To establish his position in this respect, he brings forward a mass of evidence, referring to the great difference in the *size* of certain animals of the same species, as compared with the height of different races of men, and selecting extreme cases as illustrations. Passing on to the alleged relationship, which has been found to exist between the human species and the ape, in consequence of the close resemblance between the skeleton of the aboriginal Australian and that animal; he remarks that such doctrines may be very convenient for our settlers in justifying their treatment of the natives, as though they belonged to the animal races; but he quotes several well-known travellers, to show that many of these degraded aborigines possess all the perfect attributes of Europeans.

He says also (on the authority of Dawson, Cunningham, &c.), that individuals brought to England had been educated to become true gentlemen, but that "*owing to the prejudice of colour exhibited towards the negro in all colonies, especially in English ones,*" it was no wonder that when these "gentlemen" returned to Australia, they fell back into their pristine barbarism. He thus seeks to show that the most degraded races of men are susceptible of being educated; and that they present the characteristic features of *varieties*, inasmuch as they may relapse into their original condition.

Many of the author's statements concerning our Australian colonies are curious and instructive, as coming from one who writes without feeling or prejudice; for example, whilst endeavouring to show that in every respect widely different races may become approximated, he says, "In Australia the white man falls in the scale of civilization at the same time that the negro

rises;" and concludes with the observation, that "between the European and the savage of New Holland there is less psychological difference than between many individuals in one and the same *race* amongst the lower animals." To explain the diversity of human groups, there is no need, he says, "to have recourse to the hypothesis of the multiplicity of *species;* for the multiplicity of *races* and the unity of species suffice."

It would be impossible to follow the author, ever so cursorily, in his disquisition upon the *origin* of varieties and races of animals, and the influence exercised by the "conditions of existence" in their formation. The numerous instances quoted, of abnormal human beings possessing some characteristic feature, which, had it been natural, would have distinguished them as individuals of a separate *species,* are deeply interesting, and will, no doubt, be considered so by Mr. Darwin, concerning whom the author expresses himself as follows: "I regret that I am not able to dwell longer upon the work of Mr. Darwin, for there exist between my ideas and those of my learned and ingenious brother naturalist much striking similarity, and also some differences, which it would have been useful to consider. The views of Mr. Darwin grapple with the very origin of things, and it appears to me difficult for positive science to mount to such an elevation. *He* seeks to explain the derivation of every species, and causes them to proceed from an unique type, modified during an incalculable series of ages, which include the geological eras. *I* confine my researches to those species which live at this day, and have existed only during the present epoch. But what he says of the formation of *species,* I had already stated in 1846 concerning the formation of *races,* so much so, that if one word be substituted for the other, we shall be found to agree pretty nearly on all general points concerning this order of facts."*

It will be seen from the foregoing extract, that M. de Quatrefages attributes the formation of *varieties* and *races* to the causes assigned by Mr. Darwin for that of *species;* indeed, he does not hesitate to employ many of Mr. Darwin's phrases, such as, for example, "the struggle for existence," &c.

One of the instances that he gives, of the degree of variation to which races are liable under changed external conditions, is so novel and characteristic, that we feel sure it will be interesting to the reader, and we therefore extract it *in extenso.* He is describing the transition from the Anglo-Saxon to the Indian type, as exhibited in the Anglo-Saxon-American, and says, that—

"Already in the second generation these traits of the Indian type are visible, which cause him to approximate to the Iroquois and Cherokees. Later on, the glandular system is restricted within the narrowest limits of its normal development; the skin becomes dry as leather, loses its warm tint, and the rosy colour of the cheeks, which is replaced in the man by a lemon yellow, and in the woman by a faded pallor. The head shrinks in its proportions, and becomes round or pointed, and covered with long, sleek, dark-coloured hair; the neck elongates; there is a great develop-

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* Lest this extract should lead any of our readers to suppose that Mr. Darwin has only reiterated the opinions (with modification) of M. de Quatrefages, we must add that our author distinctly states that notwithstanding the curious coincidence referred to, Mr. Darwin could not have known of his opinions which were expressed in his lectures, but not published.

ment of the zygomatic (cheek) bones and of the masseter muscles. The temporal fossæ are deep; the jaws massive; the eyes deeply set, and approaching one another very closely; the iris is dark-coloured, and the glance piercing and savage. The shafts of the bones, especially of the anterior extremities, are long; so much so, that in France and England a special form of glove is manufactured for the American market, having the fingers exceptionally elongated. The cavities of these bones are small; the nails soon assume a lengthened and pointed shape. The pelvis of the woman approaches that of the man in form. We have softened down some of the harsher features in this description."

The next link in the author's chain of reasoning, whereby he would prove the unity of the human species, is the production of *hybrids* and *mongrels*. The former, as is doubtless well known to all our readers, are the results of an intercrossing of two individuals of two different *species*: the mule, for example, being the *hybrid* of the horse and ass; whilst, on the other hand, *mongrels* are derived from individuals of different *races* or *varieties*, of which numerous instances present themselves in our races of domesticated animals.

With reference to these phenomena, the evidence adduced by the author serves to show that the production of mongrels is always easy, however greatly the races may differ from one another. It takes place daily between individuals left entirely to themselves, and man has often more difficulty in preventing than in promoting the intercourse. Neither does it interfere with the fertility of the offspring, which is equal to, if not greater than that manifested in the union of individuals of the same race.

Hybridism, or the intercrossing of *species*, is in the immense majority of cases impossible, even where the two species brought into relation with one another present the most striking affinities. "It is extremely rare amongst free, or wild individuals, and in captive or domesticated species it is brought about only with the aid of manœuvres, which often fail to produce a result. Under its influence, even in the most favourable cases, fertility (almost with one exception only) becomes irregular, and is sometimes diminished to an enormous extent."

Much space is devoted by the author to the consideration of these phenomena, and he seems almost to have exhausted the subject, for his evidence is drawn from every conceivable source. His dissertation upon the past and future operations of man, and the influence which he exercises in the formation of hybrids and mongrels, is deeply interesting, and well deserves a passing notice. He asks whether it will ever be possible to produce fertile hybrids, and his reply is, "*probably* not;" but "the power of man is very great, and less than all others are we disposed to assign to it limits based upon our present knowledge. This power has already been strikingly exhibited in the order of facts to which we have referred. There is not known a single case of hybridism between *wild* species," (*i.e.*, spontaneous crossing of species in the wild state,) "but man has obtained fertile unions, not only between species that have submitted for centuries to his domination, but between those which it is difficult to tame, between the tiger and lion. He has done even more, when, after innumerable fruitless attempts, he has at length created *series* of hybrids."

In concluding his remarks on hybrids and mongrels, the author says that if we ascend in imagination to the origin of mongrel races, we find them

then, if she happened to be at the top of the house at the time, there was no need that any one should intimate their visit, for the indications thereof pervaded the whole dwelling, and she soon called out to the servants "to put the natives out!" For the *other picture*, we will allow M. de Quatrefages to choose his subject amongst those enlightened audiences to whom his eloquent discourses are delivered, and then let him show us any two individuals, in the same race of *animals*, which present so wide a difference as do these.

The author, too, exhibits a little weakness, in refusing (as he often does) to admit palæontological evidence, excepting where, as a special pleader, it answers his purpose so to do; for instance, in the case of the remains found in "bone caverns." And again, we cannot reconcile his admission of the possibility that man *may* one day be able to form *new species*, as well as new varieties, with the contents of his chapter on the *fixity* of species.

But if these be indications of feebleness or contradiction in his argument, they are more than atoned for by the boldness with which he enters the enemy's camp; takes up the weapons of Mr. Darwin, and employs them to defend the "immutability of species" in general, and the unity of our own.

What influence our author's reasoning will have upon the views of the naturalist referred to we are unable to conjecture.

Will Mr. Darwin clip his wings, and cease to speculate? or will he thank M. de Quatrefages for having accompanied him thus far on his journey, and bidding him farewell, travel on alone?

Will he believe in the fixity of species, or exclaim: "In comparison with your extra pairs of toes and fingers, transmitted from generation to generation, or with your scaly skins, inherited by one family after another, my elongations of the neck or legs are mere trifles"!

He may say, "It is you, not I, who create new species by 'hereditary transmission of peculiarities,' the 'struggle for existence,' and your '*milieu*;'" or he may, on the other hand, agree that what *he* has regarded as a permanent moulding, and, as it were, a creative cause of new species, is only a wise modification of existing species within the limits of varieties and races, to adapt them to the varying influences of nature.

We are not a partisan; and leave our two eminent inquirers to reconcile their differences, and seek earnestly to arrive at the truth.

After what we have said, we feel sure no further recommendation of M. de Quatrefages' book is necessary. It is the work of a great naturalist, a pleasing writer, and a most instructive teacher, and (as already stated) is sure of a welcome in England whenever it shall be translated into our language.

THE OPHTHALMOSCOPE.*

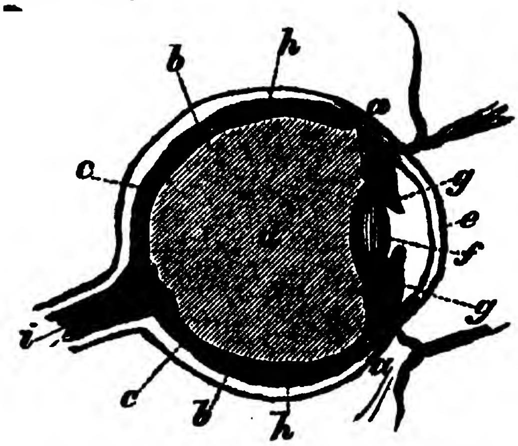
THE reader must acquit us of the desire to perpetrate a pun, when we say that nowadays every art and every science has its peculiar "scope:" zoology and botany their microscope; physics its telescope and gyroscope; photography its stereoscope; ornamentation its debuscope;

* "A Practical Treatise on the Use of the Ophthalmoscope." By J. W. Hulke, F.R.C.S. Churchill.

and the practice of surgery has, besides others, its stethoscope and its *Ophthalmoscope.* A few words of explanation as regards the last-named, (an instrument which derives its designation from two Greek words, signifying "to behold," and "the eye,") will probably be interesting to some of our readers.

First, however, it will be necessary for us briefly to consider the structure of *Nature's* wondrous and perfect instrument, which is in this case the active as well as the passive agent—the observer and the object of investigation,—we mean the human eye,—and then we shall be able to understand more clearly the mode in which the other instrument is applied.

The eye has been aptly compared to the "camera" of a photographic artist, and we shall find that a survey of its parts fully bears out the analogy.



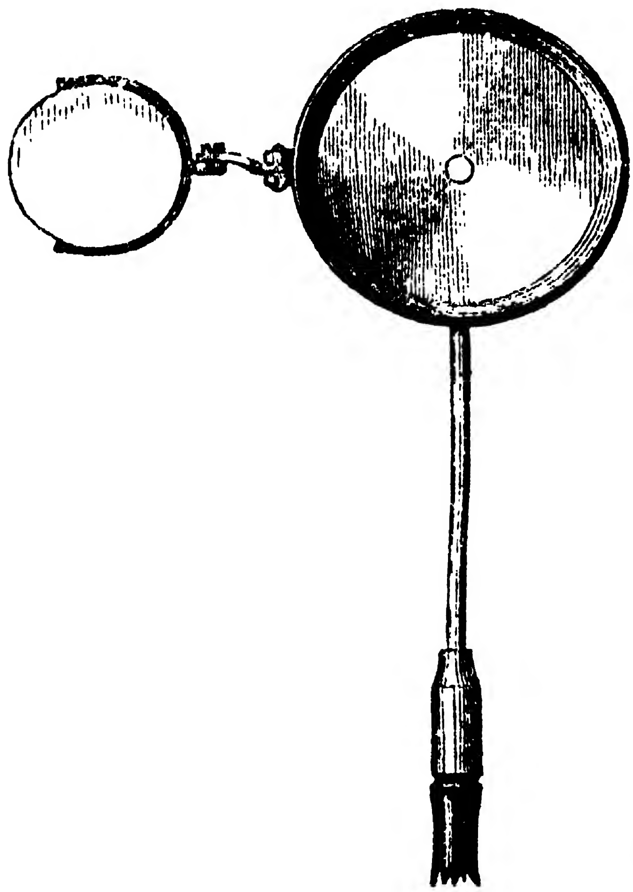
The whole of the posterior portion (see woodcut, from *a a*) backwards constitutes the *box* or dark chamber, the walls of which are composed of an outer membrane of a milk-white colour and firm fibrous consistency (the sclerotcia, *b*, *b*), and of an inner one (the choroid, *c*, *c*), in which the colouring matter (pigmentum nigrum) is deposited, that darkens the inner portion of the chamber. The last-named is however not empty and hollow as in the camera, but it is filled with a jelly-like transparent substance (*d*) (the vitreous humour), which allows a free passage to the rays of light. Anterior to (*a a*) the chamber, we have the analogue of the brass tube and lenses of the camera. There is the external lens (the cornea, *e*), between which and the "crystalline" lens (*f*) we find the curtain or diaphragm (*g g*), possessing, in the eye, that remarkable power of contraction and dilatation whereby more or less light is admitted, as circumstances may necessitate, and which is called the "iris," in consequence of the hues imparted to it in different individuals by its contained colouring matter. Between the outer lens (cornea) and the inner one (crystalline lens), is the "aqueous humour," a limpid fluid which fills the anterior chamber; and, lastly, as the reader is well aware, there is the aperture in the iris or diaphragm—the window of the eye we might term it, if it were not better known as the "pupil;" being so called on account of the little image which it reflects of him who examines it.

We have thus all the essential parts of the camera; or, to speak more correctly, the camera has many of the essential parts of the eye (for we have only named a few of the most prominent); and now we require in the latter, the "sensitive plate," which receives impressions of external objects. This is found in the *retina* (*h*), a delicate membrane, lining the whole of the concave surface of the "choroid," and over which are distributed innumerable ramifications of the *optic nerve* (*i*), which pierces the back of the eyeball a little below the posterior extremity of its axis. The retina it is that receives the external image after it has passed through the several media already named,—the cornea, pupil, lens, and vitreous

humour; and thence the image is conducted by the optic nerve to the brain. The retina, too, is that portion of the eye in whose examination the power of the ophthalmoscope is most successfully employed.

The instrument is a very simple one, and its action is easily understood; it is in fact nothing more than a little concave metallic mirror which reflects a bright light into the pupil of the eye, and it has a small hole pierced in the centre, through which the oculist may look into the eye of his patient. A magnifying lens placed between the mirror and the patient's eye, so as to enable the oculist to examine any symptoms of disease that may present themselves completes the simpler forms of the instrument.

A reference to the following woodcut will assist the reader to form an idea of the mode in which it is applied. The illuminating agent is a jet of gas conducted from the wall by means of a flexible tube, and surrounded by a chimney of blue glass to moderate the light. The rays falling upon the polished mirror are reflected into the eye, into which the observer looks through the small hole in the mirror and also through the magnifying lens that intervenes between the observer and the eye of his patient, and which he can adjust according to his wishes.



Should the reader desire to know more on this interesting subject; to study the optical principles concerned in the operation of the instrument, or the various forms which it has assumed in the hands of skilful opticians and oculists; should he wish to see the "ophthalmoscopic" appearance of the interior of the ocular chamber in health or disease,—we must refer him to the able work before us, and he will find it to be one of the first order. It is not intended (as are many such volumes) as a professional advertisement for the author; but is an essay, for which a prize was awarded to Mr. Hulke by the Royal College of Surgeons in 1859. The various forms of the instrument of which it treats are exhibited in well-executed woodcuts, and the exquisite chromo-lithographs by Messrs. Day and Son, illustrative of the appearance of the retina in health and disease, require no such apology as the author considers it needful to offer for them in his preface.

Although an eminently *practical* treatise, it is, however, not exactly a popular one; but we have no hesitation in cordially recommending it for the perusal of all medical practitioners and students, as well as to reading societies, public libraries, and to such readers as are in some degree acquainted with anatomical science.

On "Food." By EDWIN LANKESTER, M.D., F.R.S. Hardwicke.

Dr Lankester's Lectures on Food have an extensive circulation. This is not to be wondered at, for they are intended chiefly for the masses—the "working classes," as they are denominated.

We affirm, without hesitation, and at the risk of incurring censure for "favouritism" towards a friend and correspondent, that this excellent little work should be carefully read by all sections of the community, by parents and children, teachers and taught.

They may, perhaps, find here and there a little tautology, which the author would have done well to avoid, or, even in the hurry of "preparing proof," a little want of elegance in diction; but Dr. Lankester is a "working man" himself, and his work, in this instance, has been to teach us concerning our daily food and luxuries, which he has done most efficiently.

Not being a man of extreme opinions, he will be heard with respect by all; and whilst we direct general attention to his work, as treating agreeably of the comforts of every-day life, tea, coffee, chocolate, spices, &c., we would more particularly recommend those chapters in which he deals with "wine, spirits, alcohol, and tobacco," to those very numerous fellow-countrymen who are either not aware of the injurious effects of over-indulgence in alcoholic liquors, or, being aware of them, have not sufficient self-control to resist their pernicious influences.

Forest Creatures. By CHARLES BONER. Longmans.

It is difficult to conceive of a tender-hearted sportsman. One cannot imagine that he who hunts a panting hare to death, or who can look on calmly whilst his dogs tear into pieces a trembling doe, is capable of feeling gentle motions.

But if Mr. Boner feels as he writes, we are bound to conclude, that a sporting man does not necessarily possess a heart of stone, and that he may be as susceptible of love and pity as his fellow-men.

Indeed, the feature by which, above all others, the work before us is characterized and rendered interesting, is the description of the love exhibited by forest creatures for their offspring. We shall extract an instance of this attachment, and the reader will obtain some idea of Mr. Boner's style of writing.

The first relates to the female of the Wild Boar; the second to that of the Roebuck :—

"But generally the female parent fulfils her duties with true maternal care, and leads and watches over her offspring with tenderness and anxious love. Directly she hears one cry, she hastens to the spot. She calls them around her as a hen her chickens, if their safety seems threatened; and when danger approaches, she sets off with her family scampering after, to lead them where they will be secure. She does not stop till there is no fear of pursuit. She leads the way, and hastens on with an occasional grunt, which many indicate displeasure at being disturbed, or an admonition to her family to keep close. When she stops, they stop, and are as still as she. Though such matters must be new to them, and they can know little or nothing of the necessity of caution, the young things stand and listen as though they understood all about it. But onwards their mother

leads them, with a grunt as a signal for retreat, and she must be far from the spot where danger first menaced, and have reached the shelter of some protecting thicket, before she will stop or let her little ones stray at will.

"There is no peril that will daunt her when her young need defence. Her courage is then quite heroic. No matter who the spoiler be, whether man well-armed or brute of superior force, she flies at him with a fury which it is difficult to withstand. Nor will steady resistance or desperate wound keep her back or make her retreat. Not till her child be safe, or till she herself sink before her foe, does the combat end. For, as to driving her back, you might as well think of making a robbed lioness turn, as to expect her to cede, while life remains. And, as was said above, her bite is terrible; she tears out pieces of flesh, and tramples on her fallen adversary. She returns also to the attack, and does not wound in passing, and then go on, as the male animal will do. Hence, with her, it is useless to step aside, or get behind a tree, as you would, if the boar were to rush upon you; she is not to be evaded thus. When he attacks, and there is no other help, you may fling yourself flat on the ground, and you are safe, for the boar cannot wound downwards, but rips upwards only, as he passes and goes on. But she, were you to try such a stratagem with her, would turn it to her advantage and your sorrow; for you would never get up again whole and sound; may be, not rise at all. Yet the he and the she-boar, if let alone, will harm no one; on the contrary, they fleė at man's approach."

The work contains matter for a lengthened review, which, however, our space will not afford; and those who are interested in the account of the Eagle, and the hairbreadth escapes of Eagle-hunters; or in that of the Boar, Roe, Deer, Cock of the Woods, &c., must purchase the volume, which they will find to be written is a very pleasing style, and illustrated with tolerably good wood-engravings and lithographs. The scientific information is meagre; indeed, the author states in his preface that it is wholly without scientific pretension.

SCIENTIFIC SUMMARY.

QUARTERLY RETROSPECT.

DURING the last month, the scientific world has lost one of its noblest and most useful denizens. We believe that in thus designating the late Consort of our Queen, we are paying a more just tribute to his memory than if we were to rank him amongst the noble patrons of science. He was the noblest patron of science in the land, but he was also one of its most able and earnest devotees; and when his nobility shall be forgotten, his reputation as a man of intellect and a patron of mind will remain immortal.

Prince Albert attained to many posts of distinction during his lifetime; and it must be universally acknowledged that in every such case he occupied the position to which he was entitled by his intelligence.

He was the originator of Industrial Exhibitions in England, and for this alone any other man would have received a degree of homage, such as the Prince never sought nor accepted. He died Chancellor of one of our leading Universities; and in the year 1859 he was nominated to the highest scientific office that can be held by an Englishman; namely, the Presidency of the British Association for the Advancement of Science; and it is agreed, without a dissentient voice, that he acquitted himself honourably in this difficult and exalted position.

At various times we have been witnesses of the interest which he manifested in educational establishments of less pretensions than those referred to; and doubtless many of these will seriously feel his untimely departure, for it will assuredly be long before his place is supplied by his equal in worth and talent.

But let us not range ourselves by the side of those who see in his decease a cause only for regret and lamentation; nor be content to deplore and murmur over the loss that has been sustained by the country. Let us rather reflect how much better and happier he made the nation during his lifetime; what a favourable influence his modest usefulness must have exercised upon the minds of his children, who will have constantly increasing opportunities for well-doing; and let us take the lesson to heart, and consider how, surrounded by all the temptations of luxury, and of an exalted position, he prepared for himself, through a well-spent life, a smooth pillow for his last hours in a mortal state, and a happy home in eternity.

But another man of worth and talent has also recently departed this life. There are few living men who have done so much in the cause of science as the late Professor Quekett; and he too attained considerable eminence in his own sphere.

In 1856, he succeeded Professor Owen as Conservator of the Museum of the Royal College of Surgeons, but he only obtained this appointment at a time when his health was such as to render his promotion of little avail, and, indeed, too late to be of any service in ameliorating his worldly condition, or providing for his family.

Professor Quekett, like many more men of science, gave himself up for the world's benefit, and now leaves his offspring dependent upon the world of which he was the benefactor.

Two distinct committees are already formed to raise a memorial for his services; the one consists of Professors Owen, Busk, and other well-known men of science, and the honorary secretary is Lionel S. Beale, Esq. (King's College); the other was set on foot by the Microscopical Society, of which Professor Quekett was one of the founders, and Jabez Hogg, Esq., 1, Bedford-square, acts as secretary.

It is proposed that the money subscribed be invested in the hands of trustees to accumulate until the general education of the boys is complete, and they enter upon the profession or occupation of their choice, when a fourth part of the accumulated fund will be devoted to forwarding the interest of each in the manner which may seem most desirable.

We can heartily commend this object to such of our readers as are disposed to render a just tribute to a good as well as a talented man, and feel sure that the amount raised will be wisely husbanded by those who have the matter in hand.

The scientific progress of the last three months will be found recorded in the following papers :—

ASTRONOMY.

THOSE who have been charmed with the aspect of the heavens on a clear night, and the thousands of lustres which adorn this grand spectacle, should, at the least, show their gratitude by taking part, as far as lies in their power, in noticing the phenomena which are continually passing in those regions. We may particularly draw attention to such observations as can be made with the naked eye, as on the shape and dimensions of the Zodiacal light, at the ordinary extremity of which Goldschmidt detected a further very faint light the last few years; to the falling-stars and other meteors; to the Northern Lights; but more particularly to the stars themselves, and the changes of lustre which take place among them. This last subject is, indeed, one of the most interesting to which the attention can be directed in so far as regards amateur astronomy. When we look over a good celestial globe, or series of star maps, in which those objects visible to the naked eye are inserted, in order to find out the names and positions of the different stars and constellations, even during this primary instruction, we learn that the commonly-received notion of the existence of only six classes of stars visible to the naked eye is some-

thing very like a fiction, and that very few are exactly of the same brilliancy. Should the amateur arrange the stars visible without a telescope according to their brightness he would discover another remarkable phenomenon,—viz., that the stars are not equally constant in their light, but that many have been discovered to be variable; and it is very probable that many more remain to be detected, even of those visible to the naked eye. Thus, Beta of the constellation Perseus varies from the second to the fourth magnitude and back again in less than three days; Lambda Tauri changes nearly a magnitude in four days; Eta Aquilæ, in seven days; Zeta Geminorum returns to the same brilliancy every ten days; Beta Lyræ falls from the third to the fourth class, with singular changes of light, and returns to its original lustre every thirteen days; Alpha Herculis passes from the third to the fourth magnitude, and back again to the third every sixty-three days. Chi Cygni is visible to the naked eye at its brightest epoch, and almost unseen in the most powerful telescopes at its faintest time; it has a period of 397 days. In addition to those stars (all of which are easily found by help of a map of stars or a celestial globe), there are others which are visible at the present time, and on which many valuable observations might be made with unassisted vision, such as Epsilon Aurigæ, Alpha Orionis, Alpha Ursæ Majoris, Eta Ursæ Majoris, Alpha Cassiopeiæ, and Alpha Hydræ. Perhaps the most remarkable of all the variable stars is Omicron, or Mira Ceti, as it has been called, which has a period of 332 days. It is one of the brightest stars in the constellation of the Whale at its maximum brilliancy, being frequently, though not always, at that time of the second magnitude, whence it becomes completely invisible. Although favourably situated at present, it is now invisible without the assistance of a telescope, having arrived at its greatest brilliancy at the commencement of August, and being only visible to the naked eye for about 130 days. In addition to those objects, there are upwards of fifty well-determined telescopic stars which vary in lustre, more or less, and of which the following can be observed at present by those who possess telescopes:—T Hydræ (R.A. 8h. 48m., Dec. 8° 37′), with a period of 292 days, varying between the eighth magnitude and invisibility, arrives at its probable greatest brightness on Feb. 22, 1862; U Virginis (R.A. 12·44, Dec.+6°19′) will probably arrive at its maximum magnitude of the seventh order of brightness on Jan. 4, 1862; S Tauri (R.A. 4h. 21m., Dec.+9° 38′) will become visible on March 11, in *good* telescopes, when it arrives at its greatest lustre of the tenth magnitude. S Virginis (R.A. 13h. 25m., and Dec. 6° 28′) has a period of 368 days, and may probably become visible to the naked eye on May 15. R Tauri (R.A. 4h. 21m., Dec.+9° 51′) varies between the eighth magnitude and invisibility, will arrive at its maximum on May 7. U Capricorni (R.A. 20h. 40m., Dec. 15° 17′) with a period of 412 days, arrives at its maximum of tenth magnitude at the end of February, 1862. These, of course, are only a sample of the riches of this class of objects, and the amateur will find much pleasure in following up and noting their changes. And although he may not find the winter temperature very agreeable, still, however, our insular temperature will not descend to the degree of cold noted by Winnecke, whilst observing the variable stars last winter

at St. Petersburg, when the thermometer fell to 22° below zero of Fahrenheit's scale.

Babinet says, that every clergyman and every schoolmaster should be the possessor of a telescope, and occasionally give those under his care an idea of the inexhaustible riches of nature. It is only with that instrument that some of the above observations can be made; and until the optical millennium arrives many will remain ignorant of the appearances of the sun, moon, and planets; of the structure of the nebulæ; of the clusters and double stars. Some ingenious and inquisitive minds may wish, however, to construct an optic tube, through which some of the wonders of the heavens may be seen; and a German astronomer of note recommends the following as a cheap non-achromatic comet-seeker:—For the object-glass, obtain a plano-convex of two and a half inches in diameter and thirty inches focus. The eye-glass is constructed of two lenses. That nearest the eye would be of an inch in diameter and two and a-half inches in focus; and four inches from it, and between it and the object-glass, would be another of two inches in diameter and five inches in focus. The whole apparatus might be placed in a tin tube, blackened inside; the two lenses composing the eye-piece to slide in a separate smaller tube. This will give a field of four or five degrees, and magnify about ten times, and will show the stars in the Pleiades and the sword-handle of Perseus very well. It is to be remembered that, in an achromatic telescope, it is the object-glass which is the principal affair. Having obtained that, the purchaser can have the tube, eye-pieces, and stand, fitted up at his discretion. But it must be confessed that much care should be used in buying an object-glass, as a bad one, with its twirling and distorted images, gives much more annoyance than pleasure to the purchaser; and a good maker should accordingly be chosen for this most important part of the telescope.*

Encke's comet, after having been 390,000,000 of miles away from the sun, has returned to sight; and on Feb. 6, of 1862, will only be 32,000,000 of miles from that luminary. It may be seen with a small instrument, at the beginning of the year, by making use of a common star-map, with the lines of right ascension and declination marked as usual, on which the following places of the errant body are marked:—

	Right Ascension. H.	M.	Declination. DEG.	MIN.	
Jan. 1	22	17	3	7	North
„ 6	22	16	2	31	„
„ 11	22	14	1	39	„
„ 16	22	9	0	19	„
„ 21	22	0	1	52	South
„ 26	21	44	5	30	„
„ 31	21	17	11	1	„
Feb. 5	20	47	17	23	„

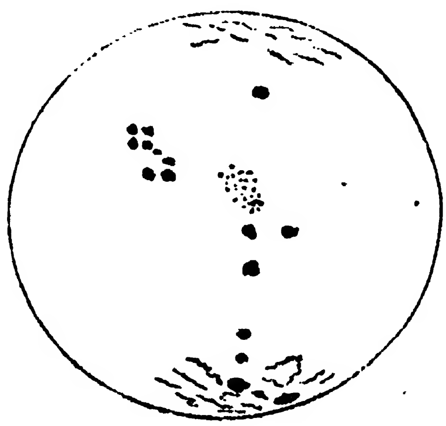
* To those who do not wish to try the *experiment* of constructing a telescope at little or no cost, we recommend a small instrument made by Messrs. Parkes and Son, Birmingham, the cost of which is less than £4. It is mounted upon a cast-iron stand, and sold in a convenient box. It has afforded us great pleasure—in enabling us to examine the more prominent objects in the heavens. There are doubtless other equally good and cheap instruments.

It has been known to be visible to the naked eye when nearest the earth. It was detected on the 23rd of October in America, by Bond, but might have been seen several weeks earlier. It was excessively faint in November, and its appearance bore out the idea of its almost ethereal nature, which a French philosopher describes as its bearing the same relation to the earth in weight as a fly to an elephant, and even adding a superlative to the lines—

"Quid levius plumâ? Pulvis—Quid pulvere—Ventus,
Quid vento? mulier—Quid muliere? Nihil."

It will astonish many to hear that the great comet of July is still in sight, but only the most powerful bodies can reach it. It is now in the constellation of Lyra. Its place, on Jan. 1, 1862, is 18h. 47m. R.A., and 49° 7′ of north declination.

The Sun has been covered plentifully with spots during the whole of the present year, but at the beginning of December they were especially in great number. On December 7 and 8, upwards of thirty could be counted, which were of all sizes, and one of which had a great latitude :—



The equatorial regions were quite clear, and the zone of the spots was very definite, and, as at this time of the year, arranged in a straight line. The bright streaks were very brilliant near the spots and edge of the sun.

An eclipse of the sun (in which about one-half of its disc will be hidden) occurs on the last day of the year, beginning at Dec. 31, 1h. 51m. P.M. at London, and ending at 3h. 51m. P.M. It is to be observed in Africa, where it is total, by the Moorish astronomers, who so carefully noticed the phenomena in the eclipse of July, 1860, in the same country. The transit of Mercury, of Nov. 11, was invisible in London and its neighbourhood, and appears to have been somewhat unfortunate in Europe, generally.

The attention of telescopic observers will mostly be directed to Saturn, whose ring will be invisible until Jan. 31, after which time it will remain in sight until May 17, when it again disappears. The mountains and atmosphere of Venus will, doubtless, also attract their gaze, and the varying bands and atmosphere, and the changeable lustre of the satellites of Jupiter, be also strictly watched. Venus arrives at its greatest evening brilliancy on Jan. 21, and will be at its greatest morning brilliancy on April 2. It is in conjunction with the sun on Feb. 25. The discovery of new planets and comets appears to have ceased lately, but will, doubtless, be resumed with the clear weather and dark nights of the coming year.

CHEMISTRY.

I. Pure Chemistry.—Although no very striking discovery has been made in this department of science during the last few months, many subjects of minor interest have been investigated, and results obtained which are of considerable value to the student of science. Foremost among these must be placed the researches of M. Stas upon the atomic weights. The experiments embodied in his paper have occupied several years; their object being to test the accuracy of the hypothesis that all the atomic weights of the elements are multiples of that of hydrogen. The complete memoir is, perhaps, the most important chemical paper which has ever been written; and in respect to the very ingenious processes devised by the author for avoiding all chance of error, the enormous labour attending the purification of the materials used, or the almost fabulous accuracy of the results when compared one with another, these researches of Stas will always be regarded as a masterpiece of analytical research. Were the memoir confined to the abstruse scientific point, the decision of which it has for its object, a more than passing notice of it would be out of place in the pages of a popular review of science; but, like many other investigations by a real master in science, the incidental matters touched upon are of the greatest interest and value to practical men. Stas is the first who has set to work in earnest to prepare absolutely pure materials on a tolerably large scale, and in this he has been beset with so many unexpected difficulties, that it is not too much to affirm that perfect chemical purity is a thing hitherto unknown. He gives the most minute instructions for the preparation of absolutely pure hydrochloric, nitric, and sulphuric acids, water, ammonia, chloride of sodium and potassium; metallic silver and lead; and by the careful details which he gives on this subject, and also by his tests for ascertaining the presence of impurity in any of the above chemicals, Stas has conferred a lasting benefit upon all scientific inquirers. Already we find that he has raised the standard of so-called purity in several manufacturing works, whilst photographers, as well as practical chemists, are applying his processes for the preparation of metallic silver and its nitrate for their own purposes. As a result of this laborious investigation, Stas has been led to the conclusion that there is no numerical relation whatever between the atomic weights of elementary bodies.

Dr. Andrews has published the results which he has obtained on exposing the non-condensable gases to the combined action of great pressure and low temperature. By employing the elastic force of the gases evolved in the galvanic decomposition of water as the compressing agent, he succeeded in reducing oxygen gas to $\frac{1}{300}$th of its volume at the ordinary temperature of the atmosphere, and subsequently effected the same object by mechanical means. The gases, when compressed, were always obtained in the capillary end of thick glass tubes, so that any change they might undergo could be observed. The pressures applied were only limited by the capability of the glass tubes to resist them, and, as a further means of effecting condensation, the gases were exposed, in their highly compressed state, to the action of a freezing mixture, which would reduce their temperature to $-106°$ Fahrenheit. By this means,

atmospheric air was reduced to $\frac{1}{675}$th of its volume; oxygen gas to $\frac{1}{554}$th of its volume; hydrogen to $\frac{1}{600}$th; and nitric oxide to $\frac{1}{650}$th. None of the gases exhibited any appearance of liquefaction, even in these high states of condensation, notwithstanding that their densities must have been but little inferior to that of water.

Professor Graham, in continuing his researches upon the diffusion of liquids, has discovered a new means of separating substances which have, with difficulty, yielded to the ordinary processes of chemical analysis. By allowing complex organic and inorganic liquids to *diffuse* through a parchment-paper diaphragm, he finds that they separate into two classes, which he terms *crystalloids* and *colloids*, the process of separation being called *dialysis*. By the dialytic method of analysis, arsenic has been removed from a complicated organic solution, soluble silicic acid for stone-preservation has been separated from the accompanying salts, and many other equally important but hitherto difficult separations have been with ease effected.

Some remarkable experiments have been performed by Dufour on the alteration in the freezing and boiling points of liquids. By preparing a liquid of the same specific gravity as water, but immiscible with it, small globules of water would remain floating about with perfect freedom of motion in the centre of the mixture. The medium employed by Dufour was essence of cloves, to which a few drops of oil had been added. By then carefully applying heat to this liquid, a temperature far above the boiling point could be attained without causing the ebullition of the globules of water; small spheres of water, of half an inch or more in diameter, being readily brought to a temperature of 300° Fahrenheit without alteration, whilst smaller spheres could frequently be heated to a temperature of 350° without entering into ebullition, although at this temperature steam has a tension of eight atmospheres. At these high temperatures the globules were as calm and limpid as at the ordinary temperature; but when carried against the side of the vessel, or touched with any solid body, an explosive formation of steam was the result. Similar phenomena were produced with other liquids, such as chloroform, &c. In a like way it was found that the freezing point of water could be retarded.

By cooling the medium in which the aqueous globules were floating in equilibrium, the water could be reduced to twenty or thirty degrees below the freezing point without solidifying. Ultimately they became suddenly converted into solid lumps of ice; and this change could always be effected in them by contact with solid bodies. As in the former experiments, this persistence of the liquid condition under severe cold is not confined to water: sulphur, phosphorus, and naphthaline, all present similar phenomena; and were it not for the difficulty in finding suitable media, it is likely that many other substances would be affected in the same way. It is likely that these researches will throw considerable light on the formation of hailstones, and many minerals which show traces of igneous fusion.

II. Applied Chemistry.—Gorup-Besamez informs us that ozone, when properly employed, is a most effective agent for restoring books or prints which have become brown by age.

His process is to place a bit of phosphorus in a wide-necked glass carboy,

and pour on it as much water as will nearly, not quite, cover it. The jar is then closed with a cork, and allowed to stand from twelve to eighteen hours. At the end of that time, the air in the jar is strongly impregnated with ozone. Then, without removing the phosphorus, or water, the engraving to be restored is moistened with water, and being rolled up, it is hung in the middle of the vessel by a piece of platinum wire, and left at rest. In a little time all the parts of the paper not covered by ink are rendered white; it is then removed, and carefully washed with water containing a little soda.

Our juvenile readers will, doubtless, feel considerable interest in some recent researches by Professor Plateau on the figures assumed by a liquid mass when the action of gravitation is removed; not, however, for the sake of the curious theoretical conclusions at which he has arrived, although these are very remarkable, as for a practical hint which his paper contains, and which they will doubtless not be slow to put into practice.

The Professor had discovered that some of the experiments, which he had hitherto been able to try only with great difficulty upon liquid media, inclosed in other liquids of the same density, could be readily performed in the air by forming the liquids into thin films; by converting them into "soap-bubbles," in fact. It was, however, necessary that some more stable kind of bubble should be obtained than the one with which we are all familiar, and which rarely lasts two minutes; and after much trouble the following liquid was prepared:—One part, by weight of Marseilles soap, previously cut into thin shavings, is to be dissolved by heat in forty parts of distilled water, and the mixture filtered after cooling. When this is effected, three volumes of this liquid are mixed, by violent and continued agitation, with two volumes of glycerine; it is then allowed to stand. The liquid, which is at first clear, begins in a short time to grow turbid, and after some days a white precipitate will be seen to have risen to the top of the liquid. Draw this off with a syphon, and preserve in a stoppered bottle for use. If a bubble be blown with this liquid, by means of a common tobacco-pipe, one may readily be obtained, four inches in diameter, and if this be supported upon an iron ring, one and a half inches across (previously wetted with the *glyceric liquid*), it will remain unbroken for three hours or more in the open air of the room; and for three days even, if protected under a glass-shade. There is a peculiar charm in the contemplation of these figures—so slender, almost reduced to mathematical surfaces—which make their appearance accompanied by the most brilliant colours, and which, in spite of their extreme frailness, endure for so long a time.

Analytical chemistry has recently done good service to the poorer inhabitants of London. It is known that, scattered about in different parts of the City, there are numerous pumps which generally possess a reputation in the neighbourhood for more refreshing, sparkling properties than are enjoyed by the water companies' supply. Dr. Letheby, as Medical Officer of Health for the City of London, has however dispelled all these pleasing illusions, and has disclosed the frightful state of the impurity of these much-admired drinking waters. He has been devoting much time to the chemical analysis of the water from these wells, and has shown that the coolness of the beverage and the briskness of its appearance are dangerous fascinations, for they are both derived from organic decay. Dead and decomposing matters have

accumulated in the soil, and have been partially changed by its wonderful powers of oxidation, and thus converted into carbonic acid and nitre; these have given to the water the agreeable qualities which are so deceptive. In reality, the water from the city pumps is far worse than that from the muddy river from which it is in great part derived; indeed, it may at any moment become charged with the active agents of disease; for no one can say when the salutary influence of the soil may fail by being worn out or over-taxed, and then the putrid organic compounds will pass into the wells unchanged. Many of the pumps are in close proximity to the fat graveyards of the City, and it is more than probable that all derive a portion of their waters from these sources, for they are the principal gathering grounds for the surface springs; in fact, they are the only open spaces through which the rain can percolate to reach the shallow wells. Besides organic matter, these waters contain large quantities of common salt, which clearly points to the presence of the filthiest contaminations from sewers and cesspools. It is the organic matter, however, which is most to be dreaded; the former are simply repulsive, but the latter is, or may be, fatal, for these organic corruptions in waters have frequently been proved to be, and may now become at any moment, the immediate cause of Asiatic cholera. This is no fanciful nor theoretical danger, for Dr. Letheby gives numerous instances in which this plague has attacked only those who used water from a certain favourite pump. In 1854 there was a sudden and serious outbreak of cholera in the parish of St. James, Westminster, and out of seventy-three persons who died during the first days of the visitation, sixty-one had been known to drink the water from a pump in the neighbourhood. Moreover, amongst persons in the same street, or even the same house, those only were attacked who employed this water, whilst others, who lived at a distance from the parish, and had the water sent to them because of its supposed goodness, were seized with cholera and died. Upon the attention of the authorities being drawn to this circumstance, the well was examined, when it was found that the neighbouring cesspool had leaked into the well, and had communicated to it its poisonous action. Several similar instances are quoted by Dr. Letheby, and it is stated that when the source of water was cut off by removing the handles from the pumps, the further spread of the epidemic was arrested. Out of all the wells examined, only two have been found at all fit for domestic purposes; the others contain an enormous amount of impurity, and in fact can only be regarded as so many dormant centres of cholera,—liable at any moment to break out into active pestilence. The subject of the deodorization of sewage has been very successfully taken up by the authorities at St. Thomas's, Exeter. Owing to an indictment for a nuisance occasioned by their sewage outfall annoying the servants and passengers of an adjoining railway, they were about to expend £1,200 in conveying the sewage to another point, when the attention of the local board was drawn to the successful use of carbolic acid, with which Mr. McDougal disinfects the sewage of Carlisle. After some discussion, they determined to adopt the same plan. The results are most satisfactory. At an expenditure of one gallon of carbolic acid per day, costing elevenpence, the whole of the sewage is completely disinfected, and this, not only in a temporary manner, but by the power of the agent in arresting decomposition, the sewage is prevented from subsequently becoming

putrescent; decomposition cannot afterwards set in, nor can any unpleasant gases be evolved. The valuable fertilizing properties of the sewage are likewise all retained, and in its deodorized form the liquid has been applied with the utmost success to the soil, producing better crops than had ever been known before.

GEOLOGY.

One of the most interesting of recent geological discoveries is that of the "Limb-lizard" of the lower Lias, a reptile equalling in size the largest known fossil forms. It is not however its size, but its structures, which are interesting, for naturalists are accustomed to believe that every group of animals, commencing with humble forms, lives on in time attaining higher organization; and though this example does not materially invalidate that view, it shows that reptiles existed near the beginning of the secondary age, of highest type, and equal in every way to the well known Iguanodons and Hylœosaurs which mark its close. This large land lizard is named by Professor Owen, *Scelidosaurus* and included in the order *Dinosauria.* The teeth of its upper jaw passed with scissor-like action in shutting the mouth, outside those of the lower jaw, just as they do in carnivorous mammals. In form the teeth were laterally flattened, triangular above the jaw, and notched at the sides, and so presented an aspect intermediate between that of the little existing Iguana tooth and that of the cretaceous fossil Iguanodon. It is towards this latter genus that the whole of its affinities tend, and, like it, it is regarded as having been herbivorous. The only part of the head which is wanting is the extremity of the upper jaw, and to this much interest attaches; for though the skull found shows that the nostril was not near the eye, as in the associated Ichthyosaurs, but at the extremity of the snout, it remains for the wanting fragment to determine whether it will be single, as in the crocodile, or double, as in lizards.

Very little is yet known of the Jurassic land reptiles. One of the undescribed forms from the Kimmeridge clay is a monster with solid limb-bones, and unguiculate feet, which could not have measured less than a yard in length.

Dr. Dawson has lately communicated to the Geological Society an interesting discovery in the coal measures of Nova Scotia, of a species of land-shell, in abundance, of the genus *Pupa.* It is found in the under clay containing the Stigmarian roots of the Sigillaria. The same species was again found more than twelve hundred feet higher up in the series, indicating that it had survived numerous oscillations in the level of the land, and the growth and decay of at least twenty forests. Of more importance than the duration of the species is the permanence of the genus, which is, in all essential points, the same that now lives abundantly in the grass of our meadows—a duration of time comprising at least three-fourths of all that geology makes us cognizant of, not having sufficed to produce in it a single change.

Figures and a description have recently been published in the *Geologist* of a piece of bone which the editor assures us is a spear-head. It is phosphatized, and was picked up on a heap of phosphatic concretions from the Reg Crag. It is certainly of Crag age. Should the discovery of other and less equivocal weapons prove the existence of man in the Pliocene period, it would raise interesting speculations on recalling the feature of the Hindoo mythology, in which the elephant, supporting the world, stands on a tortoise, to remember that *Chelonia atlas*, which could have supported one of the elephants, which existed with it, is found fossil in the newer Miocene.

Mr. Stoddart has discovered in the Carboniferous Limestone of Clifton, near Bristol, a stratum twelve feet thick, almost entirely composed of microscopic fossils. From one pound weight of the rock were obtained one million six hundred thousand distinct and perfect fossils, besides a large quantity of broken shells and other fragments. But what gives an interest to the circumstance, is the fact that a large proportion of these specimens are minute univalve shells, of a twentieth, thirtieth, and fortieth of an inch in length. These fossils are referred by the author to the genera *Pleurotomaria*, *Turritella*, and *Euomphalus*, though without any indications, either in the figures or descriptions, of the structures which characterize those genera.

Students of star-fishes will be interested to learn that those singular Silurian forms included in the genus *Protaster*, which so nearly resemble some of our British stars, having, like them, slender arms attached to a circular disc, and having a similar structure of those arms, have been shown by Mr. Salter to have on the under side a double row of pores for the protrusion of tentacle feet, as in the common asteroid star-fishes. There is thus, as also in many of the minor points of structure, a blending of the characters of the two great groups of free star-like creatures. It is from this circumstance that the discovery has great importance. It leads to the expectation that when the contents of the palæozoic rocks shall be better known, other forms will be found bridging over the gap, till now so wide, between the two orders.

It has lately been shown by Harry Seeley that in much of the central part of England the Coral Rag is replaced by a clay. This formation has been named the Tetworth Clay. Instead of containing the fossils of the Coral Rag, it has a mixture of those most characteristic of the Oxford Clay below, and of the Kimmeridge Clay above, so that the three formations hitherto included partly in the Upper, and partly in the Middle Oolite, are so linked together as to form one great formation which has received the name of Fen Clay, from its constituting the great Fen district of Cambridgeshire and the adjoining counties. By the discovery of rocks similar to the Kelloway, though of less thickness, the Oxford Clay has been divided by the same author into upper, middle, and lower. The most important of these stone bands is the Elsworth rock, a limestone fourteen feet thick, which he regards as the uppermost stratum of the Oxford Clay series.

MICROSCOPY.

WENHAM'S BINOCULAR MICROSCOPE.

THERE is no single instrument which has exercised such an important influence upon the advance of the sciences of anatomy and physiology, whether animal or vegetable, as the microscope. This invaluable aid to the otherwise limited power of the eye, has enabled us to peer inquisitively into the details of structure even of the minutest organisms, and to discover in them wonders and beauties, in the existence of which it would otherwise be hard to believe. The microscope is daily, under the eyes of numerous diligent observers, making discoveries of new facts, confirming sound conclusions, and exploding fallacious theories; and no scientific man can in this day expect to make either name or reputation, who does not call to his aid this powerful auxiliary. The physician, no less than the scientific zoologist and botanist, derives most important assistance from the microscope, and medicine can boast almost as great an advance as the collateral sciences. It is intended that the readers of the POPULAR SCIENCE REVIEW shall be kept informed of the principal discoveries made from time to time by means of the microscope, and the Quarterly Retrospect of Microscopical Science will have for its object to keep the reader *au courant* with the ever rapidly accumulating knowledge and information upon such topics.

Seneca, who wrote 64 A.C., tells us (Nat. Quæst. lib. i. c. 7) that "letters, though minute and obscure, appear larger and clearer, when seen through a glass bubble filled with water;" and here the ancients stopped; and although one would imagine that it would have been easy to make some sort of advance upon this phenomenon, yet not a step did they progress, although it is evident from Pliny (Nat. Hist. lib. xxxiv. c. 26), that they understood the art of grinding glass.

But it appears that for seventeen centuries the glass bubble suggested to no one the possibility of improvement, nor can it be said with certainty how the Dutchman, Drebbel, or the Italian, Fontana, to whom the invention is indifferently ascribed, happily succeeded in conceiving and executing a microscope, about the year 1621. A great rarity, and costly withal, was the microscope of that day; and we may safely infer that it was but a rude contrivance. In the middle of the same century, Van Leeuwenhoek improved upon it, and achieved a great reputation from his researches, the success of which arose from the care with which he polished his own lenses. The microscope used by this eminent anatomist consisted simply of a single lens, set between two plates of silver perforated with a small aperture.

Compound microscopes contain lenses having distinct functions: one to receive the rays from the object and bring them to a focus, where an image is formed, which image is examined by another lens in the same way that the object itself is examined by the lens of a simple microscope. It is such an instrument as this which, originally poor and imperfect, has received for many years the utmost care and attention of the optician, with a view to its improvement and perfection; with what results will presently appear.

The increased colouring and distortion of the image, arising from the increased distance it had to traverse, have gradually been overcome by corresponding care in the construction of achromatic glasses ; and a series of improvements made during the last thirty years has culminated in an instrument, which for precision of adjustment and truth of definition has left scarce anything to be desired.

The optical wonder, which merits this encomium, is known as "Wenham's Binocular Microscope," so called because, instead of peering with one eye down a single tube, as heretofore, the observer has the additional comfort, convenience, and advantage of looking with both eyes down a pair of tubes, so exquisitely adjusted, that the object is accurately and beautifully defined by the combination. This is, perhaps, the perfection of microscopy, and the scientific world is deeply indebted to the well-known and remarkable skill and ingenuity of Mr. F. H. Wenham for this marvellous instrument. Like all great discoveries, the binocular microscope was not the result of a lucky accident or guess, but of patient investigation and unwearied labour, and a perseverance undaunted by failure.

The stereoscope, whose phenomena have so captivated the public mind, perhaps paved the way for the invention of a binocular microscope, for although the principles of the two instruments are dissimilar, the result arrived at was the same, viz.: to give to the object that aspect of solidity, which natural objects assume when viewed with our two eyes. The object of such a double arrangement of our visual organs being to enable us to see the same object under two aspects at the same time, these two aspects being separated by the distance between the two rays, but so combined in the brain as to produce a single image having an appearance of solidity. Now the difference between the stereoscope and the binocular microscope is simply this, that in the former we arrange two images in such a manner that we succeed in seeing them as they *are not*, whereas in the latter we succeed in arranging our two eyes, so that, looking at a single object, we see it as it really *is*—that is, relieved from the flatness which appears in objects viewed only with one eye. This, it will be seen at once, is an immense advantage, and Professor Riddell of New Orleans constructed an instrument which aimed at this result, but without practical success. Mr. Wenham then came into the field, but his first attempt, described in the second volume of "Microscopic Journal," N.S., was also far from attaining that perfection of adjustment and definition which was essential to success. France also put in a claim, and M. Nachet produced a microscope free from many of the defects of Mr. Wenham's first attempt; and for low powers this wonderfully cheap instrument answers admirably, losing, however, its clearness of definition when high powers are used.

The improved form of binocular, however, now introduced by Mr. Wenham, and which has entirely captivated all microscopical observers, does not essentially differ from his former instrument. The principal objection to that, was that the projecting portions of the object appeared sometimes to be depressed, and *vice versâ*. The essential principle in all binoculars, is to bisect the pencils of rays which emerge from a single objective, each half being magnified and sent up in a separate tube to the two eyes, and each half of course differing in perspective projection; the

practical result being, that the enlarged image has the appearance of being seen by both eyes at the same time, and at a sufficient distance to make them both useful.

In Mr. Wenham's former instrument, the bisected rays diverged when they passed the prism, so that the right-hand half of the rays reached the right eye, and the left-hand, the left. Applying, however, the fact known to stereoscopists, that the remedy for a transposition of the projecting and depressed part of the picture, when viewed through the instrument, was a transposition of the two stereoscopic *pictures*, Mr. Wenham transposed the images of his microscope, by so constructing the lens that the divided pencil of rays *con*verged, instead of *di*verging, crossing each other immediately above the objective, and thus passing, the *right*-hand half to the *left* eye, and *vice versa*, the result being *orthoscopic*,* instead of *pseudoscopic*,† as before.

The two eye-pieces are placed sufficiently near to suit those whose eyes are naturally near together, but by means of draw-tubes attached to them they may be made to diverge half an inch further, thus suiting all eyes. The chief advantage which this instrument possesses over that of M. Nachet, is that only a single refracting prism is used instead of a double system, as in the latter instrument, the definition under high powers being of course much more perfect the fewer deflections the rays have to undergo.

No one can fail to be struck with the beautiful appearance of objects viewed under the binocular microscope. Its chief application is to such objects as require low powers, and can be seen by reflected light, when the wonderful relief and solidity of the bodies under observation astonish and delight even the adept. Foraminifera,‡ always beautiful, have their beauties increased tenfold, vegetable structures, pollen, and a thousand other things are seen in their true light, and even Diatoms,§ we may predict, will receive elucidation as to the vexed questions of the convexity or concavity of their infinitely minute markings, so that both the scientific and dilettante microscopist may find work for the eyes, or food for the imagination. A very important and valuable scientific fact must not be overlooked; namely, the application of the binocular to anatomical investigation. Prepared microscopic injections exhibit under the ordinary microscope a mass of interlacing vessels, whose relation, being all on the same plane, it is not easy to make out with any degree of satisfaction; but placed under the binocular they at once assume their relative position. Instead of a flat band of vessels, we now see layer above layer of tissue; deeper vessels anastomosing with those more superficial; the larger vessels sending branches, some forward and some backward, and the whole injection assumes its *natural* appearance, instead of being only like a *picture*.

* From two Greek words, signifying "straight," or true vision.

† From two Greek words, signifying "false vision."

‡ Foraminifera are lowly organisms belonging to the Rhizopoda, the lowest type of animals. They resemble "Amœba," (see article "Lowest Forms of Life"), but are protected by calcareous shells.

§ Objects of which the true nature, animal or vegetable, is not yet defined.

In conclusion, it should be remarked that the binocular form can be adapted to any single microscope, so that any one possessing a good microscope of the ordinary form can, for about seven pounds ten shillings, have it transformed, under the workmanlike hands of Messrs. Smith and Beck, into the magical instrument known as "Wenham's Binocular Microscope."

MINERALOGY AND METALLURGY.

The Dissemination of Gold.—Mr. Eckfeldt, the assayer at the United States Mint, at Philadelphia, publishes the following curious fact:—Underneath the paved city of Philadelphia there lies a deposit of clay, whose area, at a probable estimate, would measure over three miles square, enabling us to figure out the convenient sum of ten square miles. The average depth is believed to be not less than fifteen feet. The inquiry was started whether gold was diffused in this earthy bed. From a central locality, which might afford a fair assay of the whole, the cellar of the New Market House, near Eleventh Street, was dug out some clay at a depth of fourteen feet, where it could not have been an artificial deposit. The weight of 130 grammes was dried, and duly treated; it yielded one-eighth of a milligramme of gold, a very decided quantity, on a fine assay balance. It is computed that there are under Philadelphia 4,180 millions of cubic feet of clay, and that in it securely lies 126 millions of dollars' worth of gold.

Gold in North Wales.—From time to time there has been considerable excitement respecting the discovery of gold fields within the British Islands. At one period the Lead Hills caused much stir in Scotland; and the Wicklow gold washings gave rise to the appointment of a government commission. Devonshire was advertised as having "Pactolean streams," and the "fable of Colchis" was to be realized in Cornwall. The Clogan Mine, near Dolgelly, in Merionethshire, is however really producing considerable quantities of gold. In 1844, Mr. Arthur Dean read a paper before the British Association on the auriferous veins of this district. Since that period numerous trials have been made, but every such trial has resulted in great loss to the adventurous gold seekers. It is satisfactory now to know that gold is obtained from the Clogan Mine at a profit. Mr. Readwin gives the following statement as the result of the workings up to last September:—"207 tons 8 cwt. of quartz gave 1,314 ounces of fine gold; three tons of the best of this quartz gave no less than 976·6 ounces of gold. If they added 56 ounces obtained from 5 tons in 1860, it showed a total quantity of 1,370 ounces of gold from 212 tons of auriferous mineral, being at the rate of six ounces and a half per ton." The value of this British gold was £5,300.

The Gold of Nova Scotia.—Mr. O. C. Marsh, of Yale College, gives, in the last number of the *American Journal of Science*, an interesting account of this discovery. On the Atlantic coast of Nova Scotia is a belt of metamorphic rocks extending the whole length of the province, and varying in width from ten to fifty miles. It is mainly composed of clay-slate and quartzite,

but in some parts of the district these are replaced by mica-slate, gneiss, and granite. The general resemblance of these strata to the gold-bearing rocks in other parts of the world has been occasionally noticed; but it was not until March, 1860, that any discovery of gold was made in them.

Gold was then accidentally found in Halifax county, about fifteen miles from the coast, in the bed of a small stream which empties into the Tangier river. This precious metal has since been discovered at Rawdon and Douglass, in Hants county; Gold River, near Chester; and at Lawrencetown, a few miles east of Halifax. The quantity of gold as yet obtained has been, as compared with the produce of Australia or California, small; but the auriferous track appears to be very extensive. The Tangier gold, according to Mr. Marsh, gives—gold 98·13, with silver 1·76 grains; while the Lunenburg gold gives,—gold 92·04, and silver 7·76.

Natural Oxide of Antimony.—The island of Borneo has, for some years supplied Europe with nearly all the sulphide of antimony it consumes. In connection with this mineral (the *stibine* of mineralogists) there has been found another, which was for some time rejected as useless. Upon examination, it has, however, been found to be a remarkably rich and pure oxide of antimony. Dr. Phipons has examined this mineral, and he identifies it with *stibiconise*, or the antimoniate of antimony. Whereas stibine seldom yields more than 45 per cent. of metallic antimony, the stibiconise gives above 65 per cent. of metal. This ore promises to become of great value, and it is now used as a pigment, being simply calcined and powdered, as recommended by Dr. Stenhouse in the following process:—The oxide is first reduced to coarse powder, and it is roasted for four hours, at a low heat, with free access of air, in muffles. The calcined product is then reduced to an impalpable powder, by being ground in flint-mills. This, when dried and mixed with oil, constitutes the paint. This paint has a delicate stone colour, is equal in body to white lead; it is devoid of anything hurtful to the workmen, either in its manufacture or use, and its price is considerably lower than that of white lead. One advantage of lead over every other mineral as a pigment must not be forgotten. Lead and its compounds enter into chemical union with oil, most other metals only mixing with it. This antimonial paint is said to be unaffected by sulphuretted hydrogen.

Nickel Coins.—We have recently been substituting, with many obvious advantages, a light bronze coinage for a heavy copper one. The Belgian government have passed a law deciding the future composition of their half-penny, penny, and twopenny pieces. They are to be of copper, alloyed with 20 per cent. of nickel. This produces a white metal, and the coins are small, light, do not tarnish, and are without smell.

Steel Flowers.—The inventive powers of the ingenious are ever taxed to the utmost for the purpose of supplying the wants of capricious fashion. Of late, steel flowers, and other glistening ornaments, have been in vogue. Few of those who wear them suspect the source of the peculiar shining material which forms the surface. It is the common lead ore of our mines, the sulphuret of lead, or, in correct chemical nomenclature, the sulphide of lead.

Some varieties of this ore are remarkable for the way in which they break up into small brilliant particles. This is the ore employed by the artificial florist. We learn that many tons of this lead ore have lately been used in this country and in France for this apparently trivial purpose.

Lead Pipes.—The action of water on lead has not unfrequently led to very unpleasant results. J. R. Nichols, an American chemist of some standing, calls attention to the fact, that leaden pipes are most acted upon by the water flowing through them when they are bent at an *acute angle.* Whether this is due to a change in the structure of the lead, or to the mechanical action of the water at the point where it is made to turn, is not certain. The evidence, however, is satisfactory, that the lead is more rapidly corroded at these bends than in any other part. The public should, therefore, see that the plumber twists the pipes supplying houses as little as possible; and that where a turn is absolutely necessary he should be instructed to make it as gradual as the circumstances of the situation admit, at all times avoiding acute angles.

Artificial production of Crystalline Minerals.—H. Saint-Claire Deville has recently obtained, by the action of chlorhydric acid gas upon metallic oxides, heated in a platinum boat contained in a tube of porcelain: *stannic acid* in beautiful crystals of the same form as the native oxide; *titannic acid* in brilliant crystals of a blueish tint; *protoxide of manganese* in beautiful emerald-green octahedra; *specular iron*, in fine crystals like the Elba ore; and some others. Deville suggests that gaseous emanations, as, for example, chlorhydric acid, may play an important part in geological phenomena, and may conduce to the formation of many crystalline minerals in nature.

The Indian Coal Fields.—Very loose and imperfect statements respecting the quantity of coal in India have been put forth from time to time. Professor Oldham, Director of the Geological Survey of India, now, for the first time, furnishes exact returns for the last three years.

	1858.	1859.	1860.
	MAUNDS.	MAUNDS.	MAUNDS.
Raniganj Coal Field......	5,917,000	8,949,600	8,559,097
Rajmahal Hills	219,000	843,000	1,222,860
Kurhurbari	4,000	108,182	275,256
Palamow	—	28,648	30,900
Sylhet Hills	22,319	32,498	—
Total in Maunds ...	6,163,319	9,961,928	10,088,113
„ in Tons	226,140	365,575	370,206

The other known coal-fields of India are very insignificant, and there appears to be no probability of ever greatly increasing the supply of fossil fuel in India.

The Rock Oils of America.—Considerable interest has been excited by the discovery of many remarkably productive springs of mineral oil in several

parts of America. At the present time, commercially productive springs are yielding their oils in New York, Ohio, Pennsylvania, Kentucky, and Virginia. Under the name of "Seneca oil," a petroleum has long been collected by the Indians from the Seneca Lake in New York, and sold in the towns.

In 1859, wells were sunk for the purpose of pumping petroleum in several parts of Pennsylvania, and they have been vigorously continued up to this time, many of the wells yielding ten barrels a day, and some even sixty barrels. Three hundred and forty-five wells are now bored in Oil Creek, Pennsylvania, the average production being fifteen barrels a day. According to one statement, we learn that 1,500 barrels are *daily* sent to New York, and according to another, "as many as 2,800 barrels had been put into the waggons at a railway station, near the springs, in a single month." Certain, however, it is that very large quantities of this mineral oil are obtained—that it is sold in its crude state in New York for twenty-five cents per gallon, and that when refined by distillation, it is extensively used for illuminating, and for lubricating purposes.

At Tidionte, in Warren county, on the Alleghany, seventeen wells are in operation ; these are said to produce 10,000 gallons a day. At Mecca, in the eastern part of the state of Ohio, is a large tract of oil country. Considerable quantities are also produced from wells on the Little Kanawha river, in north-western Virginia. On the Thames river, in Canada West, the supply obtained from a large tract of country is extremely large. The oil wells are mere holes in the ground, about six inches in diameter. These holes vary very much in depth, some being not more than 10 feet deep, others from 400 to 500 feet. The phenomena produced upon opening some of those wells are singular. One opened at Tidionte spouted oil and water to the height of sixty feet.

These springs of petroleum in America are principally found in the coal measures, and are referred by many to a decomposition of the coal itself. Other authorities say, "They do not seem to be of vegetable origin, but to have been formed from the animal remains of the older rocks." These questions, however, require a more close investigation than they have yet received. Similar springs—certainly not so productive—have been found in this country, in Derbyshire and the Kimmeridge shales ; and the Caithness sandstones are to a great extent impregnated with a similar product.

The ever-burning springs of naphtha at Baku, in Persia, are well known, and the Rangoon tar, as it is called, is now an important article in commerce. A reliable authority says, "At Rangoon, on one of the branches of the Irawaddy, there are upwards of five hundred petroleum wells, which afford annually 412,000 hogsheads of this peculiar hydro-carbon. Nearly the whole of this finds its way to this country, and is the source from which sherwoodole belmontine, and Price's paraffine candles are largely manufactured."

Kerosolene.—In the Great Exhibition of 1851, a peculiar coal, then named *Albertite*, was exhibited. There has been much discussion as to the true character of this mineral, and eventually it has its place tolerably well defined by its name, *Albert coal.*

By distilling this coal at a temperature varying from 600° to 890° F.,

an impure naphtha, called *Kerosene*, is produced. By careful redistillation, a very volatile fluid is obtained, called *Kerosolene*.

This is a colourless, nearly tasteless, highly refractive, inflammable liquid. When a phial full of kerosolene is grasped by a warm hand, the liquid gives off bubbles of vapour, which have a faint odour not unlike that of chloroform. The peculiar anæsthetic effect of this substance was first noticed, from its producing torpor on a workman employed to clean out a kerosene oil cistern in Boston. This property naturally attracted the attention of medical men, and the physicians of Boston are now employing kerosolene in the place of chloroform and ether, it is said, with the most satisfactory results. Beyond its value as an anæsthetic agent, this volatile liquid promises to become of great use in the arts.

PHOTOGRAPHY.

THE forthcoming International Exhibition has undoubtedly proved a stimulus for exertion among all classes of photographers, and these efforts are by no means restricted to the well-known operators of this country. We are given to understand that much space has been applied for on the part of intending foreign exhibitors, whose works will be brought into somewhat close competition with the artistic productions of our countrymen. The decision promulgated by the Royal Commissioners respecting the classification of these works of art with the mechanical drawings, models, and other illustrations of engineering science in the great building has been called in question, and warmly discussed by the several journals devoted to Photography, most of which have urged the claims of photographic artists in favour of being placed in companionship with the older and better recognized departments of fine arts. In answer to this natural and well-grounded complaint on the part of the photographers, the *Engineer* has replied by taking up arms in defence of the profession, and deemed it requisite to assert the high character of the decorative arts among the examples of which it is proposed to include the results of photography.

In reviewing the progress made during the last few months in the practice and applications of photography, the *Enamels* executed by the patented process of M. Joubert deserve to be mentioned among those of first importance. The specimens recently produced by this gentleman include examples of different styles of photography transferred to, and burnt into the vitreous surfaces of glass and porcelain, and these results are not confined merely to the imitation of the monochrome effects so well exhibited and always admired in the ordinary transparent photographs upon glass, but are equally well adapted to the representation of *colour* in subjects which have not hitherto been deemed susceptible of treatment by any previously known photographic process.

The method of proceeding usually adopted by M. Joubert is substantially the following:—A transparent positive photograph of the object to be represented is first prepared in the ordinary way, or any negative

picture can at once be made to furnish the *cliché*, as it is termed by the inventor, merely on printing by superposition. In order to prepare the glass or porcelain surface to receive its impression, it is coated with a layer of honey and gelatine or albumen, containing a certain proportion of a soluble chromate, and when dried is placed in close contact with the *cliché* of the subject desired. By the unequal action of the sun's rays consequent on exposing it to the light, the sensitive surface is differently affected, and the character of the preparation becomes so altered in those parts where the light has acted fully, that being now rendered quite dry and horny, it is incapable of retaining any of the powdered enamel colour which in the next operation is freely dusted over the surface. But in other portions of the design, where the chemical substances have been altogether protected, or only partially affected during the exposure to light, the glutinous character of the surface remains unaltered or becomes modified in proportion to the activity of the rays operating upon the sensitive preparation. It is then apparent that the plate, after exposure, will take the enamel colours more or less freely when this material in the state of fine powder is spread over the surface, and that by a judicious exercise of artistic skill it would be possible to modify not only the depth of tint produced by one and the same pigment, but also to apply different enamel colours over the several portions of the picture, and so obtain all the requirements of a coloured photograph on the same plate. It remains, finally, to burn in and develope the colours applied to the glass surface by a carefully conducted furnace treatment, which will also have the effect of destroying the organic substances originally employed in the preparation.

The discussion relative to the *composition of the photographic image* has been again revived by Mr. Malone, at the London Photographic Society. The lecturer referred to the experiments of Scheele, Mulder, Hunt, and Spiller, and to the corroboration afforded by his own experimental results in support of the view which attributes to sunlight the power of decomposing the chloride and similar compounds of silver into their component elements, the reduced metallic silver being liberated in so finely divided a condition that the dark shades of colour observed in the photograph were accounted for by the feeble light-reflecting capacity of these minute particles, and that the different tints obtained were solely dependent upon slight variations in physical structure, and had no reference to chemical composition.

The *mounting of photographs** recently formed the subject of an interesting paper, read by Mr. G. Wharton Simpson, at a meeting of the South London Photographic Society. After referring to the artistic and general considerations which should be kept in view when proceeding to mount a photographic print, the author treats of the relative efficiency and permanence of the several adhesive materials ordinarily employed in the operation of mounting. Enumerating the following substances—gum arabic, starch, dextrine, albumen, glue, gelatine, and isinglass, and for special purposes india-rubber paste prepared either with benzole or

* Or *photograms*, as they have recently been called.

chloroform—Mr. Simpson gave the preference to newly-made starch paste as being the most suitable on account of the rapidity with which the fresh paste may at any time be produced in a state fit for use, with such facility, indeed, that no inducement was offered for the employment of a sample which had become tainted and acid by long keeping.

With reference to the applicability of certain kinds of *stained glass for photographic use*, the employment of the Spectroscope appears to have done good service in the selection of suitable varieties. Mr. Crookes has reported the experimental results obtained in the examination of a series of samples, whereby, in the case of orange glass, great differences were observed in regard to their power of intercepting the active photographic rays, which by the unassisted ocular inspection were quite inappreciable.

Photography on Phosphorus.—Dr. Draper has recently published a curious process: he forms a thin sheet of phosphorus by melting it between two glasses; this is exposed to the light, and is stated to become red. Dr. Draper appears to have produced on this phosphorus plate good impressions of the solar spectrum, with all the fixed lines very faithfully delineated. Some of these prints have been preserved for many years.

This has been claimed as a new discovery; but Böckman more than half a century since found that by exposing phosphorus in nitrogen to sunshine, there was deposited upon the side of the glasses, nearest the light, a red powder. He also discovered that a stick of phosphorus, exposed to the action of the solar spectrum, was bleached by the blue and violet rays, whilst it became red under the action of the red rays.

PHYSICS.

ACOUSTICS.

Musical Notes.—Professor Zantedeschi has for some time been engaged in acoustic experiments. He has published no less than nine papers on the subject in the *Sitzungsberichte*, of Vienna. The principal object of the author has been the determination of a fixed note, to which, as to an invariable unit of measure, the notes of different instruments may be referred. He informs us that the number of vibrations per second which produce the note C is from 272 to 276 at St. Petersburg, 271 in Naples, 268 in Milan, 266 in Venice, and 268 in Vienna. Lissajous states that in Paris the number of vibrations of the note A was 898 in 1856; while Sauveur informs us that in 1715 it was only 810. Professor Zantedeschi attributes this to a molecular change, gradually developed in the steel of which tuning-forks are made. In order to eliminate this source of error, he proposes to substitute for the tuning-fork a pipe such as is used at the present time by tuners of instruments in the south of Italy. He compared a number of tuning-forks and pitch-pipes known to be more than fifty years old, and found that the former had become higher, though unequally, when compared with the latter. In order to secure the fixity of a note, Zantedeschi considers that it should be

compared with the "syren" of Cagnard de la Tour, or with the toothed wheel of Savart. By these means, especially when combined with improvements suggested by M. Zantedeschi, the stability of the note, or the amount of its error, may at any time be ascertained. In France, the A has been lowered from 890 to 870 vibrations.

Zantedeschi does not appear to be aware of investigations of, and the beautiful instruments for, determining the vibrations of a note, invented by Professor Wheatstone.

Actinism, or Chemical Rays.— M. Niepce de Saint Victor has been zealously continuing his researches on the absorption of the chemical principle of the sun's rays. He gives a very instructive result in proof of this absorbtion. An unglazed piece of porcelain (*bisque*) is exposed to sunshine, one-half of it being protected from solar influence by an opaque screen; it is then taken into a dark room, and a piece of photographic paper is placed above it. This paper is blackened over all that part which is opposite to the solarized portion of the porcelain, whereas no change is produced upon that division which corresponds with the unsunned part of the plate.

ELECTRICITY AND MAGNETISM.

Musical Sounds produced by Electricity.—Mr. George Gore has devised the following beautiful experiment :—

A circular pool of mercury, from one to three inches diameter, is formed in a circular vessel of glass or gutta-percha; this is surrounded by a ring of mercury about one-eighth to one-tenth of an inch wide, and both are covered to the depth of about half an inch with a rather strong solution of cyanide of potassium. The pool of mercury is then connected by a platinum wire with the positive pole of a powerful voltaic battery, and the ring of mercury is connected with the negative pole.

The connection being completed, the ring of mercury becomes covered with crispations or elevated sharp ridges, about one-sixteenth of an inch asunder, all radiating towards the centre of the vessel, and a definite or musical sound is produced capable of being heard, on some occasions, at the distance of forty or fifty feet. The loudness of the sound appears to depend greatly on the power of the battery. If the battery is too strong, the sounds do not occur; and they are prevented by using the solution of the cyanide in too concentrated a state.

Magnetism.—Professor Wiedemann has been engaged in an inquiry on the relation between the magnetic and the mechanical properties of iron and steel. Amongst many exceedingly curious results, he has obtained the following :—

If an iron wire be twisted during or even after the passage of a voltaic current through it, the wire becomes magnetic. When the wire is twisted in the manner of a right-handed screw, the point at which the current enters becomes a south pole; in the opposite case it becomes a north pole. If, during the passage of the current, the wire be twisted in different directions, the polarity changes with the direction of the twist. If twisted in different

directions after the interruption of the current, the magnetism produced by the first twisting diminishes rapidly.

If a voltaic current be transmitted through a magnet in the direction of its axis, the magnet will twist.

The Dip of the Needle in London.—General Sabine has shown that there has been a gradual diminution of the dip in this city during the last forty years. The following table shows the rate at which this has been going on :—

1820	70° 07·3
1830	69 39·6
1840	69 11·9
1850	68 45·9
1860	68 19·9

Lunar Radiation.—Professor Tyndall, by means of a thermo-electric pile, has been engaged in measuring the temperature of the moon's rays. These observations were made from the roof of the Royal Institution, Albemarle-street. When the thermo-electric pile was directed *off* the moon, the needle oscillated between 10° and 20°, its mean position being 15°. When the pile was turned *on* the moon, the needle oscillated between 35° and 45°, the mean position being 40°. The following results were subsequently obtained :—

MEAN DEFLECTION.

OFF THE MOON.	ON THE MOON.
15°	40°
27	40
33	40

" These numbers all show *cold*, the deflection being such as would be produced by the cooling of the face of the pile presented to the heavens ; and the result is, that *the chilling was in all cases greatest when the pile was directed towards the moon*." These results are not in accordance with those obtained by Professor James Forbes some years since.

HEAT.

On the Propagation of Heat in Gases.—Dr. Tyndall has been for some time engaged in the investigation of this subject. The researches of Melloni will be remembered, but Dr. Tyndall has considerably extended the inquiry. Sulphuric ether has been found to offer the most energetic resistance to the passage of radiant heat ; and the bi-sulphide of carbon to be least effective. Aqueous vapour also prevents the permeation of the dark heat rays. In a fine day in November, the aqueous vapour in the atmosphere produced fifteen times the absorption of the air itself. Variations in the quantity of vapour in the atmosphere would, therefore, necessarily produce corresponding variations in climate.

Magnus is also engaged in a similar inquiry, and has communicated a memoir on the subject to the Royal Academy at Berlin. As the investigations are still in progress, we shall defer any consideration of the subject until the investigators have made further advances.

LIGHT.

The analogy between the electric and sun light has been shown in a striking manner by Hervé Mangon. It is well known that plants grown in darkness, or exposed only to artificial light, are deficient in their green colouring matter; and it has always been considered that the sun's light is essential to its development. Mangon has now proved that the green matter is equally capable of being produced under the influence of the electric light. Availing himself of a powerful magneto-electric light worked by a small steam-engine, he exposed several flower-pots, each containing four grains of rye, for about twelve hours a day during five days, to the rays of the lamp. The grains, when exposed, had just sprouted, but showed no appreciable green tips. They were placed about a yard from the charcoal points, and were carefully protected during the whole of the time from external light. On the fifth day the experiment was brought to an end, when it was found that all the plants were as perfectly developed as if they had been in the open air, and all exhibited their natural green colour, and were strongly inclined towards the light. Corresponding seeds, grown in darkness for the same time, grew up perfectly yellow.

METEOROLOGY.

"*On the Distribution of Aqueous Vapour in the Atmosphere*," is the title of a paper read before the Royal Society by Lieut.-Colonel Richard Strachey. In all our recent meteorological observations, it has been the practice to separate vapour pressure from the pressure of the dry air, under the impression that the quantity of water vapour in the atmosphere influenced its pressure, as shown by the height of the barometric column. To determine the correctness of this practice, Colonel Strachey examines the hypothesis of Dr. Dalton, the observations of Dr. Hooker in the Eastern Himalaya, those of Mr. Welsh in his balloon ascents, and those by himself in Kumaon on the Himalaya, at heights varying from 1,000 to 19,000 feet above the sea-level. The quantity of vapour rapidly diminishes in the higher regions, consequently the ratios of the observed barometric pressures should be widely different at various elevations. This is not found to be the case. We must refer inquirers to the paper itself. Colonel Strachey's conclusions are thus given :—

> "Now, it follows, from an obvious mathematical law, that the entire quantities of vapour in these different cases are inversely proportional to the constant reduction of density; so that the quantity on Dalton's hypothesis, which is that represented by the observed tension at the surface, is to the quantity according to Dr. Hooker as sixteen to four, and to the quantity according to Mr. Welsh as eighteen to four—a result nearly identical with the former. *The subtraction of the observed tension of vapour from the total barometrical pressure, in the hope of obtaining the simple gaseous pressure, must consequently be denounced as an absurdity; and the barometrical pressure thus corrected, as it is called, has no true meaning whatever.*"

The Winds.—Mr. James Glaisher, F.R.S., has just communicated to the Meteorological Society a paper on the duration of the winds in each month of the year. From 1841 to 1860, Mr. Glaisher obtains entirely reliable information; before that time the observations were defective.

It has been found that the prevailing direction of the wind from 1841 to 1847 was S.W. for three months, N.W. for a month and a half, N.E. for one month, in each year; and that there was no instance of a prevailing wind from the N.W. or E. in those years during any one month. From 1848 to 1856, the prevailing winds were S.W. for four or five months generally. In 1857, it was prevalent for six months; in 1854, for seven months and a half; but in 1855, for three months only; whilst N.W. wind prevailed from two to three months, and the N.E. from two to three months also. The N.E. in 1853 was prevalent for four months; in 1855 for six months and a half; and the W. wind was prevalent for one month in the years 1851 and 1853. From the year 1857 the S.W. wind has prevailed for eight months in the year on the average. In the year 1851 it prevailed for ten months; the N.W. wind being prevalent about one month, and the N.E. about two months; while in no instance was the N. wind prevalent for any month.

ZOOLOGY AND BOTANY.

At the suggestion of Professor Owen and of Mr. Panizzi, the Trustees of the British Museum have decided to remove the Natural History collection from that institution. It is not yet decided in what building or locality it will be deposited.

The Ray Society.—Dr. Carpenter's work on the Foraminifera, which will embrace a general account of the structure and functions of those animals, is in the press, and will be shortly issued to subscribers for 1860. The botanical subscribers will also be glad to learn that for 1861 there will be issued a translation by Mr. Conway of Dr. Hoffmeister's work on the Higher Cryptogamia. This work will have all the value of a new edition, as Dr. Hoffmeister has supplied much new matter, and also additional plates. This will be a really most valuable addition to our botanical literature. The other works announced to follow are Dr. Bowerbank on the British Sponges; Mr. Blackwall, a second part on British Spiders; Dr. Gunther on Indian Reptiles; and Mr. Douglass on the British Hemiptera Heteroptera. We must, however, express our doubts of the wisdom of the step which plunges the Ray Society into the fearful mazes of technical entomology. To the naming of insects there is truly no end.

Mr. Van Voorst has just issued a third edition of Professor Rymer Jones's "Outline of the Animal Kingdom." It contains much new matter, upwards of twenty-five new plates, and is still undoubtedly without a rival in our language on the subject of Comparative Anatomy.

Many of our readers will recollect the advent of the Siamese Ambassadors to England. They brought with them several chests of Siamese products, as examples of what Siam could sell. These were carefully deposited in the cellars of the Foreign Office. During the last summer they gave off unpleasant reminders of their existence, and the authorities at once ordered the chests down to South Kensington. Here, in company with several similar presents from Japan, they are now to be seen. A large number of

the contents of these chests found a fitting locality in the Food Museum. They consist of dried fishes of curious shapes, of all forms of Holothuradæ (Sea-Cucumbers), known as bêches de mer, of dried cuttle-fish, and various forms of marine mollusca, of turtles' bones, elephants' trunks cut up ready for soup, rhinoceros-hides for ditto, curiously shaped and cut seaweed, dirty-looking confectionery in great variety, fruits and seeds in great variety unknown to English botanists. These, in conjunction with the collection of Chinese food which has been in the Museum so long, form a very interesting illustration of the department of National Foods.

It may interest many of our readers, who will visit the Great Exhibition of 1862, to know that a collection of samples of raw produce, imported into Liverpool, will be sent up from that town for exhibition. In 1851 such a collection was prepared by Mr. T. C. Archer, now Director of the National Museum of Scotland. This is now placed at the disposal of the local Exhibition committee, by the Liverpool Town Council (to whom the collection belongs), and two gentlemen engaged in business in Liverpool have undertaken to add specimens of all new and important importations since 1851, and to supply others, imported before that date, but which may be wanting in the old collection.

Dr. Wight, the distinguished Indian botanist, has written a series of letters in the *Gardeners' Chronicle*, giving the result of his experience as director of the experimental farms for the culture of cotton in India, under the sanction of the late East India Company. He enters into the details of the methods of culture adopted in India, compares them with those of America, and points out that the American system could not be introduced into India on account of its exhausting the soil, and requiring new regions for its extension. He shows that the Indian system is one of a permanent character, and that maintains the integrity of the soil. He is of opinion that, if cotton is cultivated on sound principles, it can be as certainly produced in India as any other crop, and that eventually it will be a more reliable source of this product than other part of the world.

The Gorilla controversy has almost lost its interest. It is now pretty well understood that M. du Chaillu has not been educated a naturalist, and that in attempting to impart an air of romance to his narrative, he has given a colouring to his descriptions which is not strictly correct. Some of his critics think that he was unfortunate in finding friends in England, who by their injudicious eulogies awakened the envy of those who are ever ready to depreciate qualifications which can never be their own; and there is no doubt that some of these have been guilty of the very vices which they lay to the charge of M. du Chaillu. Dr. Gray, who, of course, is *not* to be reckoned amongst these, being a man who can afford to give credit to those who deserve it, has been his most bitter opponent; and we confess that whatever may be the doctor's "turn of mind" in criticism, we consider that great credit is due to him for having stemmed the current of public opinion, and drawn the attention of those who are not carried away by the tide of popular applause to the fact that the "traveller's tales" should be taken *cum grano salis*.

His criticisms called forth vehement assertions of innocence from M. du Chaillu, who referred to two ministers of religion as witnesses to the truth

of his statements, and declared that he should procure from them, and publish, a verification of his narrative. We notice that he is said to have received their replies to his application, but they have never been published. On the other hand, witnesses have come forward to prove that his journeys, said to have occupied several months, could not have taken as many weeks.

How much of this is true, we are unable to say; but, after comparing his works with those of Dr. Livingstone, and carefully weighing the testimony of the participators in this controversy, we can only regret that so enterprising an adventurer should have injured his own reputation, and have done such mischief to the cause of science generally, as he has done by not adhering to a narrative of his adventures and discoveries, which would bear the strictest investigation.

Professor Owen has published his views on the Origin of Species. They differ from those of Darwin chiefly in the nature of the causes by which species have been produced; and especially in acknowledging a Divine Author of the laws, by which he conceives all forms of life to have been developed.

GENERAL SCIENTIFIC NEWS.

The Royal Institution of Great Britain has published the programme of its lectures for the ensuing season. Professor Tyndall commences the Friday evening lectures, with one on the Transmission of Heat through Gases. Professor Rollestone, of Oxford, gives a lecture on the Affinities and Differences between the Brain of Man and the Brains of certain Animals. * This will probably open the question of the amount of difference between man and the gorilla. The Age of Man follows, in a lecture by Professor Huxley, on the Fossil Remains of Man. Mr. Denham takes up the interesting subjects of Sleeping and Dreaming. Mr. Obin, Professor of Botany in University College, delivers a lecture on the Distribution of Plants. Dr. Odling will explain the nature of Professor Graham's Researches on Dialysis; and Mr. Savory lectures on the Motions of Plants and Animals. Although not announced, we believe we are correct in saying, that Professor Faraday will deliver a lecture before Easter; the juvenile course is this year being delivered by Professor Tyndall. It will be a great disappointment to many to lose their old favourite; but we think the young folks must regard themselves as fortunate in having so able a successor to Professor Faraday as Professor Tyndall.

Sir Benjamin Brodie has resigned the presidency of the Royal Society, and Major-General Sabine has been elected in his place. At the annual meeting of the Society on St. Andrew's-day, one of the Society's medals was given to Dr. Carpenter for his physiological writings, and another to the distinguished Swiss naturalist, Louis Agassiz, for his works on natural history.

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* Some persons may be puzzled to know to *what* animals Professor Rollestone refers.

The death of Professor Quekett made a vacancy in the curatorship of the Hunterian Museum at the College of Surgeons. Several distinguished men have come forward as candidates for the vacant post, which has not yet been filled up. We have already referred to the unfortunate circumstances which aggravate the loss of Professor Quekett, and commend the subject to the consideration of our readers.

The candidates for examination for science certificates at the annual examination of the Science and Art Department, in November, were more numerous than in 1860. A great increase has taken place in the Department of Natural History. In animal physiology and zoology, upwards of thirty candidates were examined, whilst in vegetable physiology and systematic botany there were seventeen. These numbers are against six altogether, who presented themselves in the two previous years.*

* The contributors to our Quarterly Retrospect and Summary (the perfecting of which engages our earnest attention), are, at present, Mr. James Breen; Dr. Cuthbert Collingwood, B.A., Oxon; Mr. William Crookes, F.C.S.; the Editor; Mr. Robert Hunt, F.R.S.; Dr. Lankester, F.R.S.; Mr. Harry Seeley, Woodwardian Museum, Cambridge; and Mr. W. C. Unwin, B.Sc.

THE PHOSPHORESCENCE OF THE SEA.

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TRANSLATED (WITH EXPLANATORY NOTES) BY THE EDITOR.

OF all the interesting, marvellous, or fantastic spectacles presented by the sea, one of the most remarkable is, undoubtedly, that phosphorescence in which the opposing elements *par excellence*, fire and water, appear to be blended in intimate association.

From time immemorial, too, it has arrested the attention and vividly excited the imagination of those who were enabled to observe it on a sufficiently extensive scale. There never was a sailor, who, in transcribing the narrative of his wanderings, has failed to comment upon those intertropical seas in which phosphorescence is revealed in all its splendour, and where the vessel seems to plough its way through one vast sheet of flame, leaving behind it a fiery track; whilst the great zoophytes and mollusca, united in colonies and rolling beneath the waves, suggest to the observer the idea of glowing cannon-balls or masses of incandescent metal.

But is it not possible that some little exaggeration may have crept into the descriptions of these brilliant tableaux?

One would fain be tempted to believe so; and yet the reality, as it may be observed even in our temperate seas, induces me to give credence to the testimony of these eye-witnesses. But not having had the opportunity of looking upon the phenomenon developed to perfection, and only desiring to speak of what I myself witnessed, it is my intention, in the present paper, to restrict myself to an account of some of my own observations, and of some experiments that I have undertaken in order to become satisfied concerning the cause of marine phosphorescence, as exhibited in our great European harbours.

1. Description of the Phenomenon.

Most of the authors who have applied themselves to the study of marine phosphorescence, have treated only of what may be termed *diffused* or *general* phosphorescence. In this

case the light appears to suffuse the whole surface of the water; but it is necessary to distinguish between this and another phase, in which the light is visible only in isolated patches, having no connection with one another, and where the liquid itself presents no appearance of luminosity: the latter we shall denominate *partial phosphorescence*.

The first mode of phosphorescence is visible in almost every part of the Mediterranean Sea. On the shores of the ocean it has been observed at Havre, Dieppe, Ostend, and doubtless in all seaports and tranquil basins. I have myself noticed it at La Rochelle, Boulogne, &c.; but it was at the place last-named that I studied it with the closest attention. Here the phosphorescence, which is very conspicuous in the "port," properly so called, in the dry-dock, and especially at the oyster-beds,* becomes less perceptible between the two jetties, and entirely disappears where the fresh waters of the Liane intermingle with those of the sea.

The following are some of the observations made by me in the locality just named, and which being, so to speak, the highway between France and England, will doubtless be well known to many of the readers of this Journal.

However favourable the circumstances may otherwise have been for the production of the phenomenon, perfectly tranquil water was *always* completely dark. A concussion, no matter how feeble, was requisite for the manifestation of light. A grain of sand thrown upon the dark surface gave rise to a luminous blot, and the undulations proceeding from this centre were perceptible as luminous circles, becoming larger and larger, but at the same time more and more faint in proportion to their distance; just as the concentric undulations themselves became more feeble as they receded from the centre. A stone as large as one's fist produced similar effects, but in a more marked degree; and then, moreover, the drops resulting from the splash resembled the sparks flying from an anvil on which the blacksmith is welding a bar of iron raised to a white heat. Tranquillity being again restored to the surface, all returns to obscurity, and the keenest observer could detect nothing that would lead him to suppose that this water, dark even to blackness, was ready at any moment to burst into coruscations, and recognize by its phosphorescent play, the descent upon its surface even of the minutest fragment of straw. The oyster-bed was always encircled by a phosphorescent belt, arising from the constant undulations of the sea, which broke upon the beach in gentle ripples. Seen from a distance, these little waves, barely four inches in height,

* According to the project, recently adopted, for the excavation of a wet-dock, the oyster-beds will disappear: perhaps they are no longer in existence.

presented a dead white tint, which might have been mistaken for foam illuminated by moonlight; but on a nearer approach their appearance changed, and they seemed to be crowned with a faint bluish flame, comparable to that proceeding from a lighted bowl of punch. When they burst, the illumination, even as it appeared to a person standing at the water's edge, became whiter and more vivid, and the undulations often resembled waves of molten lead or iron, bespangled all over with innumerable sparks of a brilliant white, or whitish-green hue. A similar appearance was presented on the sand after the wavelets had burst; for they imparted to it a uniformly white and luminous tint, from which there appeared to spring myriads of scintillations more vivid and intense than the luminous ground. As the water became absorbed by the sand, its limits were clearly defined by a bright luminous cordon or band, which indicated the extent to which it had spread upon the shore.

When the hand was plunged into these fiery waves, and then withdrawn, it was at first completely luminous; but after a few seconds there only remained a number of glistening specks, which were, however, tolerably persistent. Water drawn from the beach, and poured from a certain height, exactly resembled molten lead, and the splashing drops presented precisely the same appearance. This luminous display was of considerable duration, and it was sufficiently brilliant to deceive the instinct of animals. During one of these nocturnal rambles, in which I was accompanied by a friend* who was aiding me in my experiments, the watch-dog belonging to the oyster-bed came bounding towards us, and barked loudly, thinking, no doubt, that he had to deal with robbers. We repulsed him with the contents of our brine-can, and in order to escape from this water, which he mistook for fire, he at once fled, and contented himself with threatening us at a respectful distance.

Another circumstance whereby we may recognize that *movement* is necessary for the manifestation of these luminous phenomena, is the following: That portion of the beach from which the tide has just receded appears, as one approaches it, to be quite free from phosphorescence; but when trodden upon, this is found not to be the case, for the concussion caused by the foot in walking, produces exactly the same effect as the stone which is flung into the tranquil water. The very ground appears to kindle under the steps of the pedestrian, and the fine gravel

* M. Bouchard-Chantereaux, one of those rare examples of the class of men who, in the isolation of the provinces, are still capable of fostering an ardent love for science, and to whom justice is seldom rendered by the learned community; for, satisfied with the acquisition of knowledge, they publish but few, if any, of the results of their arduous labours and investigations.

presents the aspect of red-hot cinders; this appearance, under the most favourable circumstances, extending at times to a distance of some inches from the impression left by the foot.

Such are the chief phenomena that accompany general or diffused phosphorescence; of a totally distinct character, however, are those which I ascribe to partial phosphorescence. In this there is nothing to remind one of the uniform tint that conveys an idea of the transmutation of the very liquid itself into the fiery element. The light is emitted only in isolated points, absolute scintillations, which usually appear and disappear with great rapidity. However numerous these sparks may be, they never by any chance coalesce; they stand out clearly from the dark background formed by the surface of the water, and their brilliancy is considerably heightened by the striking contrast. The spectacle which they produce is often a grand one. In the little channel known as the "Sund de Chausez," I have seen, on a dark night, each stroke of the oar kindle, as it were, myriads of stars, and the wake of the craft appeared in a manner besprinkled with diamonds.

At Bréhat, St. Malo, St. Vaust, and at Biarritz, I have collected similar data, and believe that I may unhesitatingly say that in those unsheltered roadsteads on the coast, which are entirely exposed to the free action of the waves, this, if not the only one, is at least the most frequent mode of phosphorescence.

It is with this kind of phosphorescence that I associate that of marine plants, so far as it has presented itself to my observation under certain circumstances; more especially as I witnessed it in the narrow channels which separate the rocks and granitic islets of our small archipelagos in Brittany.

There I have seen entire masses of fucus kindle, as it were, when roughly shaken; but even then the luminosity presented itself in isolated points, which the eye could easily distinguish. Under no circumstances did either stems or leaves exhibit the uniform glow of a metal raised to a white heat, and the water which drained from the plants was perfectly dark.

2. Causes of the Phosphorescence.

It may readily be conceived that a phenomenon so remarkable as that which is occupying our attention should early have attracted the notice both of the savant as well as of the superficial observer, and owing to that tendency of the human mind which prompts it to search after causes, before even it is conversant with the nature of effects, explanations could not fail to abound. This is precisely what has happened. It is almost needless to say that many of these solutions, hazarded at the first blush, and based upon appearances only, would

necessarily be, as they have indeed turned out, completely inaccurate.

Upon these, therefore, we shall not dwell, for it would be foreign to our object; but shall confine ourselves to the account of some of the more lucid explanations that have been attempted by various authors.

Ancient navigators appear to have attributed the light which is developed on the surface of the water to what may be termed "ordinary causes," and they believed it to be due to various atmospheric phenomena. To them, phosphorescence was the *meteor of the sea.* The foundation of this idea may be traced in the writings of some savans who have endeavoured to account for phosphorescence by purely physical action. Abbé Nollet, for example, sees in it nothing more than a modification of electrical phenomena; Bajon refers it to a disengagement of electricity, occasioned by the friction of the vessel against the waves; Tingry compares it to the *fluorescence of the diamond,* and thinks that the sea absorbs solar light during the day, which is again liberated at night.

Side by side with these physical theories may be placed some chemical hypotheses, equally void of foundation; amongst which may be reckoned those which attribute phosphorescence to "phosphoric fires," to the ignition of bubbles of hydrogen bursting at the surface of the water, &c. &c.

Another explanation of a more rational character, and probably in many cases the correct one, is that which traces the phosphorescence of the sea to the decomposition of various animal substances, more especially to that of the flesh of *fishes and cetacea.* This theory, propounded by Commerson in the manuscripts which are deposited in the library of the Museum of Paris, has reckoned amongst its advocates Bory St. Vincent, Oken, and others. As early, however, as the commencement of the last century, accurate observations had been made on the subject, and the evidence of noted travellers, together with that of eminent naturalists and physiologists, soon placed it beyond a doubt, that a great number of marine animals possess *during life* the attribute of luminosity,—the property of emitting light.

As far back as the year 1705, *Viviani,* Professor of Natural History at Genoa, had discovered in the environs of that city, and had described in a memoir devoted to the subject, as many as fourteen species of luminous animalculæ. To their presence he attributed the phosphorescence of the seas of his country.

Again, *Spallanzani* having dissolved in milk the luminous mucosity that flows from the Medusæ,* thereby rendered the

* Jelly-fishes.

first-named liquid luminous to such a degree, that he was enabled to read by the light emitted from a cupful of it.

Scharr having established the existence of phosphorescence in certain flexible polyparies, attributed to these the phenomenon in general.

Vianelli referred it to a species of Nereid;* *Rigaut*, to an animalcule at present known as "Noctiluca," which we shall consider in detail hereafter; *Henderson* to the Scyllari and Salpæ; that is to say, to Crustacea and Mollusca; and so on.

In our day everything tends to prove that the sea possesses its *phosphorescent fauna*, as does the land. Catalogues of both have been published, and will be found at the end of this paper.

That of the phosphorescent marine invertebrates was no doubt complete when it was prepared by the learned Professor (Van Beneden) at the University of Louvain, but this is certainly the case no longer. The more marine animals are studied, the more numerous are found to be those which possess the light-emitting property. I could, from my own observations, add to this list at least two or three species of Polynoë; one or two species of Syllis,† some species of an allied genus, some Crustacea, two or three species of Ophiura,‡ &c. &c.

And now, let us ask, how much of the phosphorescence of the ocean is due to the aggregation of all these forms? Undoubtedly the major portion—ay, perhaps it is to this alone that the more magnificent phases of the phenomenon must be attributed.

This assertion may, perhaps, appear strange to those who judge of the spectacle presented at sea by what they have been enabled to witness on land arising from similar causes; for there, neither Lampyris, Fulgora, nor Elater,§ has transformed the greensward into a flaming prairie, nor do these insects convert the bushes into blazing underwood.

But the sea is far more prolific than earth and air together, and produces its thousands for one that is created and nourished by the latter; as though it would justify, even in our days, the old fable in which it is designated the first parent of all living things.

In none of the observations that I have myself made on this phosphorescence,—in none of the experiments that I have tried for the purpose of testing the accuracy of my views, have I ever discovered ought but animals, and those, *living animals*. At

* A swimming worm.

† Polynoë and Syllis are also natant worms.

‡ Brittle stars.

§ *Lampyris*, the glow-worm; *Fulgora*, the lantern-fly; *Elater*, the fire-fly. These three insects are luminous; and *Elater noctilucus* is said to be occasionally used in South America in place of a candle.

Chausey, at Bréhat, or wherever else I may have established the existence of phosphorescence, I have frequently tried to ascertain the cause of those brilliant sparks which shone and disappeared again with the rapidity of lightning. In the water itself I generally found minute Crustaceans, whilst under the stones, and upon the fucus, the luminosity appears to have originated in Annelides and Ophiuridæ.

These results suffice to explain all the circumstances attendant upon the mode of phosphorescence which we are now considering. Natant, or swimming Crustaceans, which lead a wandering life, are never found congregated in sufficient numbers upon one spot to cause the scintillations of individuals to become fused or amalgamated in such a manner as to produce a uniform tint or sheet of light.

The Ophiuridæ and the most minute Annelides, owing to their diminutive proportions, are unable to emit an amount of luminosity sufficient to become united with that of their neighbours; consequently, we find the light which these animals produce, to be exhibited in points, often very closely approximate, but never completely fused together.

In the intertropical seas, or in the Mediterranean, and occasionally even on our own shores of the Atlantic Ocean, animals of larger proportions, or such as live in colonies, are found associated with those just named. These necessarily impart greater *éclat* to the phenomenon, but do not by any means change its general character. In this, as in the ordinary cases that present themselves on our shores, the partial phosphorescence is due to the presence of animals, and those animals are in a living state.

And now let us inquire, whether the same observations are applicable to *general* or *diffused* phosphorescence,—to that phase which imparts to the water, when agitated, the appearance of a fused metal bespangled with scintillations of even greater brilliancy than the glowing surface?

Whoever has merely witnessed the phenomenon would at once unhesitatingly proclaim this to be impossible. He sees, as it were, a sheet of flame spread out before him, whole waves being rendered luminous; and, having steeped his hands in the water, he finds, on withdrawing them, that they too are washed with light! Is it possible, then, to arrive at any other conviction than that this magic influence arises from some substance which is held in solution by the water?

And yet, in every case that I have investigated with the strictest scrutiny, I have found it to be otherwise. The most elaborate researches, as well as the most homely experiments, that I have undertaken, have always satisfied me, beyond a doubt, that even this mode of phosphorescence is due to living

animals; not, in this instance, to *Crustaceans*, but to *Noctilucæ*.

We shall presently revert to the special consideration of these singular forms of life, which play so important a part in one of the most splendid phenomena afforded by Nature. Let us be satisfied, at present, with observing that the Noctilucæ present the shape of little spherules, or rather of diminutive *melons*, whose largest diameter is one-third or half a millimètre.* Their specific gravity is rather less than that of sea-water. Allowed to rest in a liquid which is in a perfectly undisturbed state, they form a layer or coating at the surface, just in the same manner as a number of corks would do; but the least agitation mixes them up with the fluid which before supported them at the surface.

Now, their number is so great that it suffices to produce all the appearances already indicated. Of this the following figures will afford a sufficient proof. I once took some water from a very brilliant wave, and with it filled a tube, one décimètre (about four inches) in height. After it had been permitted to stand a few minutes, the layer formed by the aggregation of the Noctilucæ was one and a half centimètres in thickness; consequently the animalculæ constituted a seventh of the whole mass of fluid. On drawing the water from the *surface* only of a wave just breaking upon the beach (skimming it, as cream is taken from the milk), I filled therewith a large goblet. The total height of the liquid was fifteen centimètres (between five and six inches); that of the layer of Noctilucæ five centimètres, or about one-third of the mixture which I had collected. This is the highest ratio obtained by me; but at False Bay, M. de Tessau found the proportion of animalculæ to be one-half. Without taking into consideration any diversity of species which may exist in those latitudes, this estimate of numbers alone suffices to account for the far greater brilliancy of the phosphorescence there, as compared with the phenomenon with us. It is easy to comprehend how so vast a multitude of luminous corpuscles, disseminated through a body of water, may present an illusory appearance to the eye, just, for example, as the fine molecules of earth, held in suspension in the liquid which they cloud, impart to it a distinct homogeneous colour.

But here again are other experiments that place the question beyond all doubt.†

* A mètre, the French standard measure, is 39·33 inches; a décimètre, centimètre, and millimètre are respectively the 10th, 100th, and 1000th part of a mètre. The diameter of *Noctiluca* is on the average one-fiftieth part of an inch.

† Most of these experiments were first tried by Suriray, a doctor at Havre; they were repeated by Blainville and M. de Tessau; M. Verhæghe added to them, and I myself repeated and diversified them in various ways.

If water, charged with Noctilucæ, and which appears uniformly luminous, be poured into a narrow glass, or, in preference, into a tube seven to eight millimètres in diameter, it will at once be perceived that this water is illuminated only in isolated places. If the luminous points be examined with a pocket lens, the animalculæ are easily distinguishable, and it then becomes apparent that they alone are phosphorescent, whilst the surrounding liquid is perfectly obscure.

After the tube has been allowed to stand for a few minutes, the Noctilucæ rise to the surface and form a luminous layer, below which the water is totally deprived of its phosphorescence.

In order to restore to the liquid its original appearance, it suffices to agitate it slightly, whereby the Noctilucæ are once more disseminated throughout the whole body of water.

In the same manner as the naturalists referred to, I have subjected luminous water to filtration. (A rather fine handkerchief suffices for the experiment.) The Noctilucæ remained upon the linen, to which they imparted a brilliant light; whilst, on the other hand, the filtered liquid presented no signs of phosphorescence, notwithstanding every means employed to promote it. When the Noctilucæ were carefully washed from the filter, and placed in water that was previously dark, they at once imparted to it a phosphorescent appearance. Without entering into further details, I think that these experiments, which may be repeated by persons possessing even the most limited facilities, serve to show that, notwithstanding any appearances to the contrary, the diffused phosphorescence of the ocean is due to the presence of these Noctilucæ.*

But, we may be asked, whether we mean to imply that this is the sole cause of the phosphorescence. By no means. It may be that, as Newland surmises, in some cases, the spawn of certain fishes contributes to its manifestation, or perhaps, in certain exceptional cases, it may be due to some extent to the presence of animal matter, similar to that which is formed on the surface of putrefying fish, and which may become dissolved in the water, as suggested by M. Becquerel, so as to communicate to it a luminous property. Nevertheless, in the presence of facts so clearly established in Europe by several naturalists, and in the latitude of the Cape by M. de Tessau, observations of the

* It follows, as a matter of course, that the Noctilucæ may contribute to the manifestation of *partial* phosphorescence as well, when, as I have often seen them, they are greatly disseminated; and, on the other hand, it has happened that in waves presenting the uniform luminosity which I have called *diffused* phosphorescence, I have met with the more brilliant scintillations produced by Annelides and Crustaceans mixing their light with that of the Noctilucæ.

utmost precision would be requisite to confirm the varying opinions to which we have just referred. It would be necessary to demonstrate, with the aid of the microscope, that the objects perceptible to the eye were *ova*, and not *Noctilucæ* or some similar animalcules; and to prove, by means of the same instrument, the existence of an organic deposit, or, in the latter case, it would have to be shown that the water was still phosphorescent after passing through the filter.

But even if the accuracy of the theories propounded by Newland and M. Becquerel could be proved by observation and experience, in certain special cases, it would still remain an undoubted fact that the phenomenon of which we are treating is essentially due to the presence, in great numbers, of Noctilucæ.

All the researches of the past century, therefore, lead us back to the conclusion arrived at by Rigaut as early as the year 1764.

3. Nature of the Luminosity exhibited by Marine Phosphorescent Animals.

In a paper printed nearly twenty years since, and the first one published by me on the subject,* I remarked that under the designation of phosphorescence there had been grouped together phenomena essentially distinct from one another, and having nothing in common excepting the production of light. In severing *fluorescence*, and studying it as a distinct phenomenon, physicists have to some extent diminished the perplexity arising from the too general use of the former expression (*i.e.* phosphorescence); but the abuse of the term phosphorescence still exists, and nowhere is this so palpable as when it comes to be applied to the property possessed by certain living or dead organisms, of emitting light. Without dwelling upon the consideration of plant-forms, or upon that of animals deprived of vitality, we shall find that the production of light in the latter may be the result of vital actions of very different kinds.

Let us first briefly call to mind the principal views that have been enunciated on the subject. Amongst the numerous theories that have been propounded in order to account for the existence of phosphorescence in living animals, there are some that need only be mentioned to be dismissed.

In this category may be placed those of Beccaria, Mayer, &c., which assimilate it to *fluorescence*,† and who believe that the creatures emit at night the portion of the sun's rays which

* On a new mode of phosphorescence observed in Annelides and Ophiuridæ.—*Annales des Sciences Naturelles*, 1843.

† Fluorescence is, "the diffusion of light and change of colour which

they have absorbed during the day;* that of Brugnatelli, who regards it as the light *ingested with the food* (!), and penetrating to the surface through the vital organs; and even that of Gilbert, who conceives the luminosity of the Noctilucæ more particularly, to be owing to electric sparks drawn from these little creatures by the friction resulting from their passage through the water.

The researches of Spallanzani, Burmeister, and more especially those of Macaire, first cast a true light upon the nature of the phenomenon under consideration. This investigator had employed the insect races as the objects of his researches, and he expressed the opinion that the light emitted by these was the result of a slow combustion comparable to that of phosphorus exposed to the atmosphere. This conclusion has been completely confirmed by the recent researches undertaken by M. Matteucci, weighted, as these are, by the application of all the resources of modern science and the reputation of the author.

The light of the Lympyridæ (glow-worms) and Elateridæ (luminous beetles, commonly known as "fire-flies") is extinguished in a vacuum or in irrespirable gases; it reappears in atmospheric air, and becomes remarkably brilliant in oxygen gas. It is emitted from a peculiar substance possessing the same properties in the living animal as it does after its decease, until completely desiccated; and, lastly, this luminosity is accompanied by a disengagement of carbonic acid. These are all evidences of a true combustion.† But does this explanation, true as regards certain insects, apply also, to those invertebrates whose habitat is the ocean? Dugés and a great number of naturalists have thought so; but it is difficult to understand how such a combustion can proceed in submerged bodies or in fluids, such as those secreted by the Medusæ and Pholades. On dissolving the mucosity produced by the former in milk, Spallanzani rendered the liquid so luminous that he was enabled to read by the light from the glass vessel in which it was contained; and M. Edwards observed that the secretions of some Pholades, which he had placed in alcohol, formed a luminous stratum at the bottom of the glass jar in which it

takes place at the surface of some liquids and solids in consequence of a change in the refrangibility of the different rays."—GRAHAM.

* That such a phenomenon is not only possible, but actually occurs in connection with *inorganic* substances, has been shown by the experiments of M. Niepce de St. Victor, as detailed in our last number, p. 268,—"Actinism."

† The experiments upon which the author of this paper has based his observations on the luminosity of insects are at variance with those of Professor Kœlliker, an account of which appeared in the *Microscopical Journal*, (p. 166) of 1858. M. de Quatrefages has had no opportunity of reading those observations, but requested us to append an abstract of them to his paper, which we have done in a note at the conclusion of this article.—ED.

was contained. Could there have been *combustion* in these two cases? Very accurate and searching experiments, it appears to us, would be requisite before a reply could be given in the affirmative.

Lessou was one of the first, if not the first observer, who considered phosphorescence to be a distinct phenomenon, resulting from physico-chemical action, and bearing a direct relation to some *vital* act; but the expressions employed by him are far too vague to possess any practical value; and, moreover, he is himself not satisfied with his opinions, and insists upon the necessity of special researches on the subject.*

Macartney, Todd, and Coldstream, consider phosphorescence to be due to an imponderable agent, to nervous emanations modified or influenced by the action of certain organs. The last-named observer, judging by the luminous track left by the snail, imagines that phosphorus, or some similarly luminous substance, may enter into the composition of the light-producing organs.†

Moyen and Becquerel, although they admit various kinds of phosphorescence, do not explain the diversity of causes from which the phases of phosphorescence are derived. Ehrenberg, in his elaborate treatise on the subject, appears inclined to attribute all the varieties of phosphorescence emitted by animals to one sole cause. According to his views, it results from vital action, and is produced in a manner somewhat analogous to the electricity of certain fishes. He thinks that the luminous mucus is secreted in a passive state, and is called into action by luminous discharges. (?) So far the views of this eminent savant accord with some of the theories hitherto propounded; but he goes still further, and he has confirmed an important fact, which was revealed to me before I became aware of the labours of Ehrenberg; namely, that under the microscope a light, which was before steady and uniform, is resolved into a vast number of minute scintillations. Ehrenberg, moreover, attributes the production of light, in most cases at least, to the influence of the reproductive organs.

My own observations have revealed to me three different phases of phosphorescence, from which may be inferred actions of a totally distinct character, all resulting ultimately in the production of luminosity.

1. I have witnessed in *Pholades* and *Medusæ*, the secretion

* *Dict. des Sciences Naturelles*, art. "Phosphorescence."

† *Cyclopædia of Anatomy and Physiology*, art. "Animal Luminousness." Macartney and Todd think "that the luminous organs concentrate and modify the nervous influence, so as to form it into light." So that, according to this theory, animal luminousness is an effect solely of vital power; and this view is to a great extent confirmed by the experiments of Kœlliker.—ED.

of a luminous mucus, which continued to shine after its separation from the animals.

2. On two occasions only I have found *Crustacea*, whose internal substance emitted such a constant and uniform light, that, in the dark, the most minute details of organization were clearly distinguishable. No phosphorescent matter exuded from the body.

3. In the great majority of cases I have seen the light manifest itself in sparks, or scintillations, *along the course of the muscles alone; and only during their contraction.* In this case there was a production of pure light, independent of material secretion.

It is this last mode of phosphorescence, at once the most ordinary and the least to be expected, which has been the special subject of my researches.

My observations were first directed to various species of Annelides, belonging chiefly to the genera Polynoë and Syllis, and to some of the smaller Ophiuridæ, occasionally found in such great numbers under stones, and amongst fucus recently stranded by the tide.*

In common with Dugés, Ehrenberg, and no doubt many other naturalists, I have occasionally seen these Annelides and Radiates emit a light sufficiently powerful to strike an eye-witness, even without his attention being drawn to the phenomenon, and notwithstanding the illumination of a good lamp. The first-named animals more especially presented the appearance (to use an expression of Ehrenberg) of ignited cords of sulphur,—the light appearing to be uniformly distributed over the whole body.

But when they were examined with the aid of a simple lens, this uniform light was found to resolve itself into a series of luminous points placed on either side of the body, and covering the spaces occupied by the little wart-like processes which serve as the locomotive organs of Annelides.

The same appearance was presented in the Ophiuridæ. Now and then the arms (radiating members) appeared to be completely incandescent; but the lens revealed upon each of them a series of luminous specks, alternating with intervals of darkness. The *body* itself is never luminous, and these phenomena are only observable when the animal is in motion. The Annelide must be progressing, or the Ophiura moving its limbs to and fro, before the light becomes perceptible in the surrounding obscurity. As soon as either assumes an attitude of rest, the

* I regret that I did not determine the various species which formed the subjects of my investigations. Absorbed with the study of the phenomenon itself, I was unable to devote to the zoological inquiry the attention which it deserved.

luminosity ceases; motion being resumed, light also reappears.

To me these observations, which are very easy of repetition, served as a starting-point for further inquiries. Phosphorescence being so palpably associated with locomotion, it was only natural to seek the seat of the former in the muscular system. This I long essayed in vain. The employment of the microscope became necessary, and the difficulty lay in these circumstances. It was needful in the first place to adjust the instrument, so that the luminosity should be exhibited exactly at the focus; and, secondly, that the light produced should be sufficiently powerful to be perceptible, notwithstanding the subdued light requisite to reveal the parts placed under the object-lens. After much groping, and many fruitless attempts, I succeeded in surmounting these difficulties; and even whilst I write, it is a source of lively pleasure to me to recall the sense of astonishment with which I witnessed for the first time in a little Polynoë (no doubt as brilliant an example as that which Ehrenberg has designated "fulgurans"), the motor muscles of the bristles suddenly illumined before my eyes, under a magnifying power of 100 diameters.

The muscles alone emitted light, the other portions of the foot remaining perfectly obscure.

But now another phenomenon presented itself quite unexpectedly. What the simple lens had done in regard to the entire body, the microscope performed for the foot. These muscles again were not uniformly luminous throughout their entire length; but there appeared disseminated over them a vast number of exceedingly minute, but at the same time remarkably brilliant points, which appeared and vanished again with the rapidity of lightning.

The outline which they presented consisted not of an uninterrupted track of light, but of a line formed by a succession of scintillations.* Lastly, I discovered that these scintillations (and consequently the "phosphorescence" which was visible to the eye) were only emitted during the contraction of the muscles. An examination of the Syllidæ and Ophiuridæ revealed precisely the same phenomena as I had observed in Polynoë, and I therefore regard them as a confirmation of my views on this interesting subject. How is it possible that a luminosity manifested in the very recesses of the living organ-

* The author compares the effect visible in this case to that exhibited by what he terms the "magic tablet" of electricians. It is a tablet of glass on which representations are made with spangles of tin-foil, and when the discharge takes place, the figure appears in sparks of light, not in a continued luminous outline. A similar effect is produced in "Barker's spotted tube."—See Jabez Hogg's "Elements of Natural Philosophy," p. 450.

ism, in those tissues which of all others maintain the greatest amount of activity, and during their most energetic action, could bear any relation to the physico-chemical forces which we bring into play in our laboratories? How indeed can such a phenomenon be regarded otherwise than as the result of a vital act?

This was my view of the case; and here I found myself at one with Ehrenberg; but I had gone farther than he had done, for I had satisfied myself that the seat of the phenomenon was in the muscular tissue, and was closely related to its contraction.

These two entirely novel and unexpected results, however, needed verification by experiments on other animals, and I eagerly availed myself of the opportunity presented by the Noctilucæ of the port of Boulogne to subject my opinions to a fresh test. The very important part which they play in "general phosphorescence," that is to say, in the phenomenon on its grandest scale, gave a special interest and importance to their study; whilst the infinitude of these animalculæ, and even their minute proportions, afford to the experimentalist greater facilities than any that I had previously possessed.

In the first place, however, it was necessary to become intimately acquainted with the organization of the Noctilucæ themselves; and the results of this twofold study now remain to be described.

4. The Noctilucæ and their Phosphorescence.

The Noctilucæ (*Noctiluca*, Surriray; *Mammaria*, Ehrenberg) are, as we have already stated, microscopical animalculæ bearing a pretty general resemblance to little melons deeply indented at one end.

Near this depression there is fixed an appendage, which the animalcule moves slowly to and fro, swaying it from right to left (see Figs. 1 and 2, A, B.). The body is so completely transparent as to admit of its structure being studied in its minutest details. It is inclosed by two hyaline membranes, representing the *dermis* and *epidermis*.* Near the appendage these membranes present a minute orifice, which serves as the outlet from a little mass of pellucid, homogeneous, and finely-granulated substance, which is prolonged into the internal part of the body. From this mass, which forms as it were a centre, there radiate in every direction a number of rhizopodic † extensions, which become more and more ramified as they proceed, and of which the ultimate indefinitely multiplied ramifications

* The names given by physiologists to two coats of the skin.

† The reader will recollect that we had to employ this expression in treating of Amœba, &c. (of the Rhizopoda, in fact), in the articles on the "Lowest forms of Life," Nos. I. & II. of this Journal.

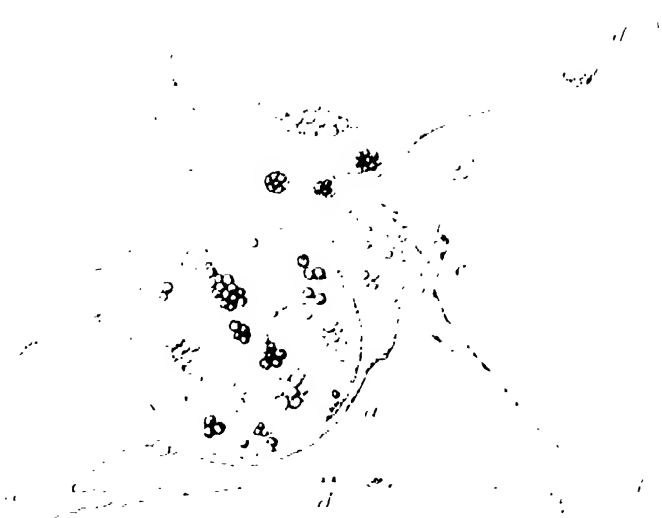
spread themselves over the whole inner surface of the animal (Fig. 1). An absolutely limpid and transparent fluid fills up the interstices, and this it is which imparts, or rather maintains, for the animalcule its general rounded form. Should this fluid accidentally make its escape through the minutest aperture, the animalcule immediately loses its shape and sinks to the bottom. The reader may form some conception of the general appearance exhibited by the remarkable internal structure of Noctiluca by a reference to Figs. 1 and 3; but in order to understand the strange spectacle which it presents in the living animal, it is absolutely necessary to watch the latter with persevering attention. It then becomes evident that neither the prolongations, nor yet the central mass from which they radiate, have any fixity of shape; that they are in continual motion, and susceptible of constant modifications. The larger branches are seen under the microscope to become attenuated, in consequence of the substance of which they are composed passing into the neighbouring ones; whilst the minute ramifications assume larger proportions, inasmuch as they borrow the materials from others in their vicinity. Here and there *vacuoles* make their appearance, and increase in dimensions, whilst others previously existing diminish in proportions, and are finally lost to view.

It will also be observed, that some of these vacuoles are formed near the orifice; that they inclose or surround* granules of green substance, or the powder of carmine or indigo, which may have been mixed with the water; then, detaching themselves by degrees from the central mass, glide along one of its chief prolongations and fulfil the functions of a temporary stomach; for they rotate with this alimentary pillule round the whole body, and finally return to the point from whence they originally departed.† In short, the little mass and its extensions are found to consist entirely of *sarcode*, that primary animal substance so carefully studied by the late lamented Dujardin, in the external prolongations Gromia, Miliola, and so many other of the marine and fluviatile Rhizopoda.‡ And

* Or, as the author more appropriately designates it, "*englober*," a word for which we have no equivalent in English.

† In the articles just referred to ("Lowest Forms of Life") we had occasion to describe these "vacuoles" as temporary receptacles for the nourishing fluid of the body; indeed the reader who has paid any attention to the subject will no doubt already have come to the conclusion that these Noctilucæ are but one degree removed from the lowly organisms described elsewhere.

‡ The Rhizopoda of Dujardin, which include the Foraminifera of D'Orbigny, are regarded as perfect animals, and form a distinct branch in the classifications of zoologists; but for my part I am convinced that they are only larval forms, and that their later stages remain to be discovered.—A. DE Q. Such of our readers as desire to study the Foraminifera, will have an excellent opportunity of doing so on the appearance of Dr. Carpenter's work, to be published shortly by the Ray Society.



now we must call to mind the fact, that amongst the most characteristic properties of "sarcode," we find what may be designated an *indefinite contractility*. Such is the entire constitution of the inner substance of the Noctilucæ, in which no other distinct organization is visible; and we shall now proceed to inquire into the nature of the "phosphorescence" produced by animalculæ so remarkable for the simplicity of their structure.

First, it is easy to recognize beyond all doubt, that the emission of light takes place independently of all contact with the atmosphere; and that it is not influenced by the nature of the gas with which they are brought into relation, provided it does not cause sudden death.

The first statement may be easily verified by collecting a colony of Noctilucæ in a glass tube, so that they form a layer of 10 to 12 centimètres (about 4 inches) in thickness. It will then be found that the column is equally luminous throughout its whole extent, notwithstanding that the uppermost portion rises almost above the surface, whilst the remainder is deeply submerged. If we go so far as to place the Noctilucæ in as perfect a vacuum as can be obtained, we find that, far from losing their luminous property, they shine with a continued brilliancy till life becomes extinct; but then the attempt to excite their luminosity, even by the admission of oxygen gas in place of atmospheric air, is quite futile: it has disappeared for ever. Finally, if Noctilucæ be placed in inverted tubes, and if we introduce severally into these tubes, atmospheric air, oxygen, hydrogen, nitrogen, and carbonic acid gas, the results will be found to be alike in each, neither description of gas affecting the luminosity in a manner different from the rest.

These experiments suffice to prove that the light emitted by Noctilucæ is certainly not the result of combustion; and the following serve to show that it is independent of any external secretion.

We have already stated that luminous water passed through linen is quite dark after filtration, leaving the luminous animalculæ upon the filtering material.

The same result follows if, instead of water, we employ milk—a fluid which becomes so readily charged with the luminous mucus of the Medusæ.

Again, if Noctilucæ be placed in ether, it remains perfectly obscure; the animalculæ forming a luminous sediment at the bottom of the tube. Again, if the hands or any object be rubbed with the Noctilucæ remaining upon a filter, it sometimes happens that luminous traces are the result. These one might be led to attribute to some luminous secretion, either internal or external; but a nearer examination with the lens leaves no doubt that these traces are due to fragments which

retain their luminosity so long as they continue to possess organic contractility.*

In short, it is to contraction, and to that alone, to which I consider the production of light attributable. This conclusion, however, was only arrived at after I had compared the results of two series of experiments—the one tried in the daytime, the other at night: these experiments being diversified, but each series in strict correspondence with the other.† Thus, I tested the action of heat, compression, electricity, and of ten chemical substances, alkaline, acid, and neutral,—the general result being that any agent whatsoever capable of causing the sarcodic substance of the Noctilucæ to contract, was efficacious in precisely the same degree and at the same time in producing phosphorescence. An isolated shock caused, during the daytime, a violent but momentary contraction; at night it gave rise to a bright but transient exhibition of light. Under the influence of continued, or of too violent irritation, the whole substance of the body is seen, in the daytime, to contract to such an extent as to become liberated from the external envelope, gradually to sink down, as it were, and become disorganized or lose its vital properties. At night, the same operation leads to a continued phosphorescence apparently pervading the whole animal, and of which the steady and permanent brilliancy always denotes approaching dissolution. Thus, contraction and phosphorescence are invariably met side by side, and proceeding, as it were, step by step.‡

The contraction may be either partial or general, and it may manifest itself in different places at the same time; so also with the luminosity. This is easily observable with the aid of a pocket lens. It is only necessary to pour water containing Noctilucæ into a tube and shake it a few times, when the little luminous spheres at once become clearly distinguishable, and their movements may be readily followed.

They will be found to present the appearance which I have sought to depict in fig. 2, A, B, and occasionally the same animalcule is seen to become illuminated at two points in succession. If the tube be repeatedly shaken, or (what is a still more

* I have ascertained the same thing to be the case in the locomotive organs of Annelides.

† By this, I mean that I repeated at night the experiments tried during the daytime, in such a manner as to be able to compare the results. Thus, for example, whatever produced contraction during the daytime, imparted luminosity at night.

‡ These experiments are not easy. The use of the compressor is requisite in their performance, and the operator must be an adept in its employment. It requires two persons to conduct the experiments by night. M. Bouchard was kind enough to co-operate with me in all these researches.

efficacious agency) if a little alcohol be added, the effect becomes very marked. The light of the whole is perceptibly increased, and those animalculæ whose entire substance shines with a steady white light, multiply considerably in numbers.

This result may be exhibited in a most pleasing manner as follows:—a long tube must be filled with water well charged with Noctilucæ, and a drop or two of sulphuric acid subsequently poured gently into the tube. In its descent this will acidulate the water, and will be found to operate as one of the most active irritants that can be applied to the animalculæ, of which it rapidly disorganizes the substance. As, therefore, this formidable drop descends, it appears to ignite the Noctilucæ in its passage, and thus its downward course may readily be traced.

Here, again, is a still more beautiful experiment producing similar effects.

If the lower extremity of a tube, replenished as above, be plunged into water raised almost to the boiling point, at the moment of its immersion not the least light is visible.

Soon, however, some scintillations are apparent at the bottom of the tube, and as the liquid becomes heated, and the warm currents rise from below upwards, the luminous animalculæ multiply in numbers. In a few moments they are all luminous, and the tube then presents the appearance of a fiery rod. This brilliancy does not, however, last long: the little illuminated balloons are extinguished one after another, and do not recover their luminous properties even if transferred to cold water. When I tried the experiment, a temperature of 39° * had killed them all.

But there are no observations connected with the Noctilucæ that will compare in beauty and interest with those which may be made with the assistance of the microscope.

In proportion as the magnifying power of the instrument is increased, we see reproduced in each animalcule the effect that we noticed on approaching the luminous waves of the sea-beach.

Examined with a power of 20 to 30 diameters, the illuminated portions of the body of Noctilucæ present a uniformly bright aspect. With 60 diameters a number of small but brilliant scintillations become visible, detaching themselves, as it were, from parts of what appears to be a pale luminous background; and these scintillations come and go with the rapidity of lightning. An enlargement of 150 diameters, however, reveals the true character of the phenomenon. It then becomes obvious that the light emitted from the whole body, or any of its parts, is composed of a vast number of instantaneous scintil-

* 39° Reaumer equal to a little less than 120° Fahrenheit.

lations, closely approximating to one another at the centre of the "phosphorescent" portions, but disseminated and clearly distinguishable at the edges. Occasionally there may be seen isolated sparks at the extreme limit of the luminous part, or even beyond it (fig. 3). In employing very fresh and vigorous examples of Noctilucæ, I have been enabled myself to inspect and to exhibit this phenomenon to M. Bouchard-Chantereaux under a magnifying lens of 240 diameters.

Thus we find in the Noctilucæ the same phenomena which we observed in the Annelides and Ophiuridæ. In neither case does the spark which presents itself consist of an unbroken body of light, but it represents, so to speak, the sum total of an infinite number of evanescent scintillations. Each luminous manifestation is a nebula, so to speak, resolvable, with a sufficiently high magnifying power, into a cluster, just as we find it to be the case in a celestial nebula. But in this instance there are no "fixed stars;" for even when the luminous point remains apparent to the unaided vision for a few moments, and the microscope is brought into play, this is not only decomposed in space, but is also resolved in *time*, the component scintillations being instantaneous and evanescent!

It is quite obvious from the facts thus revealed, that the luminosity of Noctilucæ is a phenomenon very different in character from that of phosphorus exposed to the air. No one would for a moment pretend to say that scintillations such as those exhibited under the microscope could be the result of a *slow* combustion; and an *active* combustion (which is always accompanied by great heat) could not proceed in the very heart of the living tissues. Indeed, careful experiments have satisfied me that no elevation of temperature takes place even where the luminosity of the animalculæ is most brilliant; there has been no apparent influence upon the most sensitive thermometer when plunged into a mass of these forms all brightly luminous, presenting, indeed, the maximum of phosphorescence.

In the electrical fishes, we know that there is a special apparatus for bringing into play the physical agent, *electricity;* in the Lampyridæ a particular organ secretes the phosphorescent matter: Ehrenberg has described similar luminous organs in Photocharis and Thaumantias, and Meyer in Pyrosoma.

Nothing of the kind, however, exists in the Ophiuridæ or Annelides which I have carefully investigated; nor is it the case, as we have seen, in the Noctilucæ. Here the living organism itself, and what may be termed *par excellence* the vital tissue, namely, the muscular, produces the luminosity solely in virtue of its vital function, namely, in that of contraction; and the light emitted appears to be perfectly pure and independent of any other product.

Whether or not the reader will be able to share with me the impressions left by those remarkable appearances which I have witnessed and sought to describe, I cannot say, but it appears to me that no physiologist can fail to regard with satisfaction the circumstance that *life* performs the chief part in one of the most magnificent phenomena that the eye of man can contemplate, and which has hitherto been usually attributed to the physico-chemical forces.

LIST OF PHOSPHORESCENT ANIMALS REFERRED TO IN THE TEXT.

No. 1, is from "Todd's Cyclopædia"; No. 2, from Verhœghe's article on "Phosphorescence of the Sea on the Coast in the Neighbourhood of Ostend."

I.
INSECTA.

Lampyris: L. noctiluca, L. splendidula, L. italica, L. ignita, L. phosphorea, L. nitidula, L. lucida, L. hemiptera, L. japonica.

Elater: E. noctilucus, E. ignitus, E. phosphoreus, E. lampadion, E. retrospiciens, E. lucidulus, E. lucernula, E. speculator, E. janus, E. pyrophanus E. luminosus, E. lucens, E. extinctus, E. cucujus, E. lucifer.

Bupestris ocellata.

Chiroscelis bifenestrata.

Scarabæus phosphoricus.

Pausus sphærocerus.

Fulgora: F. laternaria, F. serrata, F. pyrrhorhyncus, F. candellaria.

Pyralis minor.

Acheta gryllotalpa?

II.
MYRIAPODA.

Scolopendra electrica, S. phosphorea, S. morsitans.

Julus ——— ?

CRUSTACEA.

Cancer fulgens, &c.

Carcinum opalinum.

Erythrocephalus macrophthalmus.

Scyllarus (species doubtful).

Gammarus pulex.

Cyclops brevicornis.

Oniscus fulgens.

ANNELIDA.

Nereis: N. phosphorans, N. noctiluca, N. cirrhigera, N. mucronata.

Syllis fulgurans.

Photocharis cirrhigera.

Polynoë fulgurans.

Chœtopterus pergamentaceus.

Lumbricus phosphoreus.

Planaria retusa.

MOLLUSCA.

Helix noctiluca.

Pholas dactylus.

Pyrosoma atlanticum, P. giganteum.

Phallusia intestinalis.

Salpa zonaria, S. tilesii.

ECHINODERMATA.

Asterias ——— ?
Ophiura telactes, O. phosphorea.

ACALEPHÆ (or Cœlenterata).

Pelagia phosphorea, P. noctiluca.
Oceania Blumenbachii, O. pileata, O. hemispherica (thaumantius), O. lenticula, O. microscopica, O. scintillans.
Beroe fulgens, B. rufescens.
Cydippe pileus.
Mnemia Norwegica.

POLYPI (or Cœlenterata).

Pennatula phosphorea, P. grisea, P. rubra, P. argentia.
Veretillum ——— ?
Sertularia ——— ?
Gorgonia ——— ?
Alcyonia ——— ?

INFUSORIA.

Ceratium tripos, C. fusus.
Peridineum Michaelis, P. acuminatum, P. furca.
Prorocentrum micans.
Stentor ——— ?
Synchaeta Baltica.
Noctiluca (Mammaria) miliaris.

TRANSLATOR'S NOTES.

NOTE 1.—The following is a short abstract of Professor Kœlliker's "Observations on the Nature of the *Luminous Organs of the Glow-worm* (*Lampyris*)," (with comments on their bearings in regard to the subject under consideration,) which were translated by the writer, and published *in extenso* in the "Microscopical Journal" for 1858, p. 166.

Lampyris possesses, upon certain rings of its body, a double series of flattened luminous plates, appearing white to the naked eye, and presenting the greatest amount of luminosity when viewed from above. These organs consist of an "investing membrane," inclosing a "parenchyma" (internal substance) "composed of *cells, tracheæ*" (*i.e.* respiratory tubes), "and *nerves*." The cells which constitute the internal substance of these organs are of two kinds, called by Kœlliker "pale" and "white;" their structure is minutely described by him, also the tracheæ and nerves, of which he has carefully followed the ramifications.

We may at once here state, that if Kœlliker's observations in this respect be accurate (and he is a careful and reliable observer), the luminosity cannot be the result of *combustion*, any more than in Noctiluca, for it proceeds in the very depths of the vital organism, amongst delicate respiratory tubes, "forming the most abundant and elegant ramifications among the *pale* cells." "Now" (the observer continues), "*the proper luminous substance* does not consist in the *white* cells," but in the "*pale*" ones, "as may be readily proved by direct observation of the luminous organs under the microscope by night, when the light of the lamp is shut off."

The contents of these cells, he says, "are albuminous;" they do not contain "phosphorus," as was stated by Leydig, another observer, but a uric acid salt, probably urate of ammonia. This latter discovery Kœlliker put to the strictest chemical tests, always with corresponding results; and, on the other hand, he satisfied himself, by the employment of other tests, that no phosphorus was present.

Kœlliker believes the luminosity of the glow-worm to be dependent on the will of the animal, but not (as De Quatrefages regards that of Noctiluca, the marine Annelides, &c.) to be at all influenced by movements. He says, "Even in the night-time, individuals may be noticed performing the most active movements, and yet showing no luminosity whatever."

He tried the effects of various irritants—mechanical, electrical, thermal, and chemical; indeed, from the account which he gives of his various experiments, he seems to have treated the glow-worm much in the same manner as De Quatrefages tested the luminosity of his little Protozoans, and his conclusions are "that the luminous organs are a *nervous apparatus* whose nearest analogues may be sought in the electrical organs" (of fishes, such as the Electrical Eel, *Gymnotus*, &c.)

"All excitants of the nerves excite the luminosity, and the agents which annihilate the nervous functions act injuriously in this case also. My experiments wholly subvert the theory hitherto current, which assumes the existence of a luminous material secreted and deposited in the organs, a sort of phosphorus, which on the addition of oxygen through the respiratory movements becomes oxydized, and consequently luminous."

After showing that the tests applied by him prove that no such substance can be present, he concludes by stating that "the light is produced under the influence of the nervous system, and in all cases is maintained only for such a period, whether long or short, as the nerves, stimulated by the will or otherwise, act upon the organs."

The reader will perceive, therefore, that although this account of the luminous organs in insects (so far at least as the glow-worm is concerned) is at variance with the theory adopted by our able contributor regarding that class of animals, yet it is confirmatory of his conclusions that phosphorescence, or, more correctly speaking, "animal luminousness," is the result of vital and not of physical action. And, moreover, the investigations of these two inquirers may suggest to some of our readers, as they have done to us, the probability that the phenomenon observed by the one in the Annelides and in Noctiluca, and by the other in Lampyris, may be of a like nature. That is to say, it is quite within the range of probability that both may result from, or be influenced by nervous action, and that the "scintillations" so beautifully described by M. Quatrefages may have taken their course along the *motor nerves*.

This is an inquiry of great importance to physiologists, for if it can be established that luminosity is invariably related to nervous action (when there is no perceptible secretion of phosphorescent matter), it will necessarily follow that Noctiluca, and probably all the lowest forms of animal life in which no nervous system has yet been traced, possess at least the rudiments of one; and this is rendered still more probable in consequence of the diffused or pervading character of the luminosity in the lowest forms, as in Noctiluca

when compared with the Annelides: for in the former it is natural that where no other organs are as yet differentiated, that is, transformed or developed from what may be termed the crude material (sarcode), the nerve substance should also be diffused and without definite form.

We recommend this interesting inquiry to the attention of our readers.

NOTE II.—To such of our readers as are desirous of entering more fully into this subject, we recommend the careful perusal, not only of the foregoing observations by Kœlliker, but of Mr. Brightwell's Paper on the "Subdivision of Noctiluca" (*Micros. Jour.*, 1857, p. 185), beautifully illustrated by Tuffen West.

DESCRIPTION OF PLATE.

Fig 1. Noctiluca, as commonly observed; enlarged and seen by transparent illumination. *a.* Motile appendage; *b.* mass of granular substance closing the orifice of the general cavity, and from which the sarcodic extensions are seen to radiate.

Fig. 2. Enlarged Noctiluca seen in darkness. *a.* Phosphorescent in parts; *b.* phosphorescent throughout its substance; *c.* phosphorescent portion of a Noctiluca, seen with an enlargement of 240 diameters.

Fig. 3. Portion of the sarcodic substance of Noctiluca exhibited transparently, and enlarged 150 diameters. *a.* Large vacuole inclosing particles of green matter, and of carmine, swallowed by the animalcule; *b.* smaller vacuoles containing liquid only; *c.* parts of sarcode containing vacuoles that have collapsed—this portion of the body is amœba-like (constantly changing its form); *d, d, d, d,* extensions of the sarcodic mass, also variable in their character.

THE SUN AND SOLAR PHENOMENA.*

BY JAMES BREEN, F.R.A.S.

DURING the past year the Sun has been in an extraordinary state of perturbation, and it need scarcely be added that those observers who take an interest in solar phenomena have been in a corresponding degree of excitement. The surface of the great central luminary has broken out into an eruption of dark spots, and the telescope can scarcely be pointed towards it for a moment without our perceiving several clusters of those irregular and strange-looking blotches which dim its otherwise glowing orb. No alarm, however, is created among astronomers by the unusual number of those specks; their return in such plenty is purely periodical, and it is not in the least expected that they will go on increasing indefinitely, but rather that they will gradually diminish in dimensions as well as in numbers during the next five years; again, however, at the lapse of this interval, to recommence the cycle of their wonted appearance in more considerable groups. It is not in the least feared that the sun's light will be obscured or its heat lessened by those motes which are commingled with its beams; it will still germinate, nourish, and ripen fruit and flower,—still produce rain and whirlwind,—still purify and revivify our atmosphere by lighting,—still go on effecting those mighty changes on land and water which render our globe habitable. Lagrange has proved and foretold the invariability of the seasons on the earth. Equally satisfied are observers that, notwithstanding the continual changes on its surface, they shall see for ages yet to come the sun's light reflected from planet and satellite during the night in the same degree as they see its fiery glow from hill and dale during the day. Its light, passing through showers of ice-crystals in the distant summer atmosphere, will continue to produce those white circles (or halos, as they are termed) visible at times round its luminous disc; by means of the sprinkled water-drops it will still paint in colours of unequalled splendour the brilliant rainbow, which, like hope, may rest upon the darkest and most sombre cloud in the heavens. The rosy fingers of Morn shall still open the

* With an account of the Eclipse of the Sun in 1860, as seen by the author in Spain.

curtains of the East, and the crimson sunset still make its appearance, whilst both will preserve their usual tints as if this violent agitation proceeded not on the surface of the sun.

The *statistics* of the sun's weight and distance and size are so well known, that it may here appear out of place to repeat those data. As an illustration, however, of its overwhelming size, we may state, that if all the planets of the system were rolled up into one mighty ball, still, however, this would appear a mere pigmy in comparison with the vast globe of the sun, which would fill a space some six hundred times larger than this great collection of matter. If the heavy rocks and minerals of the interior planets were macadamized and mixed up with the clay and sand and water of the exterior ones, it would be found that, light as are the materials of which the sun is composed, its mass would outweigh not less than 738 of such fictitious globes piled up in the opposite scale. It would take more than 350,000 globes like our earth to weigh it down. The ocean of fire which surrounds it is more than 20,000 times greater than the surface of the Pacific Ocean, and more than 12,000 times greater than the area of the whole earth. The domain over which it presides would be considered marvellously great were we ignorant of the vastness of the starry spaces, or of the infinite number and distances of those luminous objects of which the sun in all its glory represents but a single unit. In comparison with those spaces, which a ray of light takes years to traverse, how small is our distance of ninety-five millions of miles from the central body,—how small even the distance of the exterior planet Neptune, when, representing the vast dimensions of the sun by a ball only two feet in diameter, and preserving the same scale throughout, we should have Neptune about the size of a plum at a distance of a mile and a quarter from the body round which it revolves!

In the telescopic aspects of the other planets we perceive many striking similarities with the economy of our own globe: mountains on Mercury and Venus, snows on Mars, trade-winds on Jupiter and Saturn; the alternations of day and night, and many signs of the existence of atmosphere, on all the planets. They are illumined by the same light, warmed by the same heat, and pursue their courses around the same fixed star as the earth. But another world opens when the attention is directed towards the sun. The blue and limpid atmosphere of the earth bears no analogy with the dense and fiery crust which surrounds the solar orb. Immense openings, more like the bursting forth of a volcano, where the lava is thrown aside in torrents and the whole surface is a sea of liquid and seething fire, have no similarity with the feathery clouds or drifting masses of light vapour which are seen in the atmosphere of

the other bodies of the system. Imagine a degree of heat some three hundred thousand times greater than that which exists on the earth, and which would turn our purest metals into fumes. No end of wild conjectures or grand conceptions can be made in connection with the scenery of this new world.

> What wonder, then, if fields and regions here
> Breathe forth elixir pure, and rivers run
> Potable gold, when with one virtuous touch
> Th' arch-chemic sun, from us so far remote,
> Produces, with terrestrial humour mixed,
> Here in the dark so many precious things
> Of colours glorious and effects so rare.

It must not be forgotten, however, that the principal error of those who start theories on the light and heat of the sun,—who would reduce those elements to material fuel and agency,—has been in their supposition that the sun and planets—the donor and the recipients—are bodies of a similar nature, and that the same conditions are general throughout the system, whether it be star or planet, satellite or comet.

Those who have looked at the sun with a telescope of even moderate power, have of course observed the dark spots on its disc. They have seen them of every conceivable size and form, and it very seldom happens that they have any appearance of regularity further than that they are commonly approximately circular. These spots are surrounded by a lighter shade, which is mostly of the same form as the central speck, and which seems like a fringe of less-dense material, parting abruptly from the more obscure kernel which it incloses. This intermediate shade does not mix with the densely black nucleus, at the same time it is distinctly separate from the illuminated surface of the sun. This is most strictly true in every instance: the *nucleus* or spot proper is of one tint, and that a very intense black; the *penumbra*, or fringe, of an equally constant though much milder degree of shade—a sort of half-mourning; whilst the brilliant lustre of the solar surface makes a third tint. There are thus three distinct and sharply-defined grades, and these facts must be strictly borne in mind by all those who would endeavour to explain the physical constitution of the sun. Sir W. Herschel accounted for it in this manner: The outer luminous surface which it blinds us to look at he considered is composed of a fiery and cloudy matter supported by a transparent medium similar to our atmosphere. When the bright envelope, either from volcanic disturbance or other agitation within, or from currents from without, is broken, we perceive the upper portion of the inner atmosphere illuminated by the light which it receives from above, and at the same

time we see through the opening the dark body of the sun itself. There can be no doubt but that the spots are pits or holes gradually shelving down into the sun's body. This can be immediately seen by following any well-defined and round spot as it is carried across the disc by the sun's rotation on its axis (in 25¼ days); but the above explanation is, after all, only a conjecture, though the most plausible which has been broached on the subject. Secchi has measured the depth of those wells, and found them to be about one-third of the diameter of the earth, or about 2,600 miles in profundity. After an attentive study of the spots, Sir John Herschel says:—"The idea conveyed is more that of the successive withdrawal of veils—the partial removal of definite films—than the melting away of a mist, or the mutual dilution of gaseous media. Films of immiscible liquids having a certain cohesion, floating on a dark or transparent ocean and liable to temporary removal by winds, would rather seem suggested by the general tenor of the appearances; though they are far from being wholly explicable by this conception, at least if any considerable degree of transparency be allowed to the luminous matter."

But having gazed, to his heart's content, at the nuclei and penumbræ, the observer will, no doubt, scrutinize the remaining portion of the sun—the luminous surface, with much interest. Here, again, new variations of light and shade meet his gaze. Let him first take the whole surface of the sun into view; he will at once observe that at the edges the light becomes gradually dimmer, and that the contrast between the centre and the margins is very great in this respect. By placing a sheet of paper (instead of the eye) a short distance from the eye-piece of the telescope, when an image of the whole surface of the sun is obtained, this difference of luminosity is immediately perceived. It is argued from this, that there is an atmosphere extending considerably beyond the apparent surface of the sun, imperfectly transparent, which prevents the solar light from coming to us with the same intensity whilst traversing great thicknesses and different strata of air, with that where it passes in a simple and direct line, as through our zenith, or the centre of the sun. With this luminous surface of the sun no other light can compete. The most brilliant artificial flame appears as a patch of smoke on the disc of the orb of day. It has been found that the brilliant light given forth by the ball of ignited quicklime (invented by Lieut. Drummond) is only equal the one 146th part of the light at the surface of the sun. M. Foucault has, however, by passing the current of the voltaic pile through certain metals, found in the electric light produced, when decomposed by the prism, brilliant bands superior in brightness to the corresponding bands furnished

by the rays of the sun. Scrutinizing this luminous surface with high powers, we further perceive that the light is not uniform, but that it is covered with bright points, giving it a porous appearance, which has been aptly compared to the skin of an orange. At the last meeting of the Royal Astronomical Society, a photograph, taken by Mr. De la Rue, was exhibited, which represented this rough surface with the greatest accuracy, much more perfectly than could be possible in any engraving. Those bright specks very frequently attain to much greater dimensions, and are often visible, particularly at the margins of the sun, under the form of long serpentine and bright blisters, much more lustrous than the ordinary surface of the sun, however bright that may be. All these are as changeable as the spots. These bright streaks (or *faculæ*) are proved to be considerably elevated above the surface of the sun. Thus we find that if the sun exercises great influence on the surface of our globe, it must be acknowledged that its own atmosphere is equally disturbed, though the causes of those changes are less explicable. The spots and bright streaks are continually appearing and disappearing, varying in form and size, breaking up or collapsing every hour. Sometimes they take the form of a whirlpool, and even seem to have a sort of spiral or rotatory motion. Any observer, with a fair telescope, is able to perceive all those phenomena; and in no other subject of practical astronomy is the aid of the amateur so useful in determining the positions and annual number of the spots. To another object constantly accompanying the sun, but best seen in our latitudes during the spring evenings or autumn mornings, the services of the amateur are very valuable. We allude to the cone of faint light seen after sunset or before sunrise along the ecliptic, and which has hence obtained the cognomen of the zodiacal light. Humboldt has searched in vain for any allusion to it previous to that of Childrey, in 1661; but an admirer of Shakspeare might, perhaps, think that this phenomenon was described in the lines,—

> "Yon light is not daylight, I know it, I:
> *It is some meteor that the sun exhales,*" &c.

in contradistinction to the breaking light of morn. The keen eye of M. Goldschmidt was able to detect, at the last appearance, a faint offshoot from this mysterious light, and which was observed on the same night at a different part of the world. To those endowed with sharp vision, the systematic observation of the direction and dimensions of this object would be a matter of much value. (See the accompanying engraving of a large spot, and the *faculæ* visible in February.)

One of the Elizabethan dramatists says, "Better to bless

the sun than question why he shines." Notwithstanding this, how many conjectures have been formed on this subject! Our forefathers, who were ignorant of the voltaic pile and electricity, attributed the light and heat of the sun to material fire. May there not be other agencies unknown to us which would explain the incandescence of the sun? An eminent authority, whilst favouring the idea of a perpetual electric discharge, frankly confesses that every discovery of this kind seems "to remove further the prospect of probable explanation." In addition to the energetic action of the currents of the galvanic pile, other remarkable ideas have been started. It has been demonstrated by Thompson and Watherston that if five pounds of cosmical matter were to fall on each square foot of the solar surface, and the body was going at the rate of 390 miles per second, that the heat and light resulting from the shock would be sufficient to account for that actually existing on the sun. Those falling bodies must be searched for in the shooting stars, and probably in the zodiacal light. Messrs. Carrington and Hodgson have witnessed a phenomenon which favours this conjecture (a portion of the solar surface blazing suddenly for an interval of about ten minutes), yet the theory which attributes the lustre of the sun to the continual formation of torrents of electricity engendered by the clouds of the various envelopes, would seem to obtain the greater number of suffrages among astronomers.*

It might be added that, as the northern lights sensibly affect the magnets, it has been noticed that the phenomena connected with the sun also appear to exert a certain influence on them. General Sabine has shown that the maximum variation of the needle corresponds with the greatest abundance of the solar spots. The dependence of the magnetic intensity on the solar altitude is well known; and it has also been found that the earth's magnetic force is greatest at those seasons when our globe is nearest the sun. Admiral Smyth may well say, on this subject, that a "wonderful coincidence seems to be satisfactorily established therein, a mine is sprung, the extent of which he is a bold man who will venture to predict, although inductive experience is allowed to adopt the tone of prophecy."

* Professor Thomson considers that meteoric action is the only explanation which can be given in respect to the heat and light radiated by the sun. Chemical action is insufficient to account for it, whilst meteoric action depends on independent evidence. The former could generate only about 3000 years' heat, the latter would account for twenty million years of solar heat. And what a degree of heat too—sufficient to keep up a 63,000 horse power. Each square yard of the solar surface representing the consumption of 13,500 pounds of coal per hour, and where forty feet thickness of ice would thaw per

It will be seen that the various phenomena of spots, whether dark or brilliant, and all the different changes in their form and motion and number, are not mere objects of idle curiosity, but intimately connected with the economy of our own globe. Should the persevering observer merely count the number of spots which he remarks on the solar surface in the course of a year, he would confer a boon on science. If, in addition, he accurately determines their positions by Mr. Carrington's plan, the series of observations would be extremely valuable. That eminent observer has discovered a law of storms in the sun's atmosphere, there being a daily drift of the spots in longitude which reveals a general equatorial current of thirty degrees in breadth in the direction of rotation, whilst a reverse current of nearly the same breadth is perceptible beyond it in each hemisphere. We are indebted to M. Schwabe for a systematic reckoning of the number of spots visible since 1826. In 1828 the number of groups was 225, which gradually diminished to 33 in 1833. In 1837 they had increased to 333; and in 1843 they had fallen to 34. By 1848 the number had again increased to 330; whilst in 1856 only 34 were visible. In 1860 they had increased to 210; and in the years 1861 and 1862 will, doubtless, be greater. It must be remembered that all these changes are gradual. The periodicity is undeniable, and may be reckoned at about eleven years, though it does not appear to be constant, sometimes amounting to nearly fifteen years (as the minima of 1784 and 1799), sometimes being only 8½ years (as the minima of 1689 and 1698). The observer will perceive, too, that the zones of disturbance are different year by year: sometimes the spots are confined wholly to the sun's equator; at other times wholly north, sometimes altogether south of the equator. They seldom pass beyond forty degrees of latitude. That they are intimately connected with the rotation of the sun on its axis there can be no doubt, but that it is solely due to this cause is impossible. There must be external atmosphere or internal agitation to cause those immense ruptures (one of which was measured at 3,780 millions of square miles in area) which precedes the effect produced by rotation. The amateur astronomer will see what a rich field is

minute. At the Cape of Good Hope, under a vertical sun, only one inch of ice would melt in 2h. 12m. 42s. It may be added that according to the theory of Mr. Watherston, the *debris* and fragments of broken material which would fall and batter into the sun would (if of the density of granite), cover the surface to a depth of twelve miles annually, whilst according to the hypothesis of Professor Thomson, a thickness of twenty-four miles would fall into it, from the matter of the Zodiacal light coming in contact with its photosphere.

opened to him in the path of discovery by diligent observation of the solar spots alone, remembering

> "No earnest work
> Of any honest worker, howbeit weak,
> Imperfect, ill-adapted, fails so much
> That 'tis not gathered like a grain of sand
> To enlarge the sum of human action used
> For carrying out God's end."

Strange to say, it is when the sun is entirely hidden from view (as during the darkness of a solar eclipse) that we become best acquainted with its clouds, its atmosphere, and the general phenomena of its surface. Look at those two illustrations representing the appearance of the sun, or rather the light surrounding it, and the moon at the last two solar eclipses of 1858 and 1860. What strange forms are beheld in the halo or glory about the moon! What are those crimson flames? Are they our old friends the bright streaks of light—the faculæ? Is it this corona or glory which is the suspected outer atmosphere of the sun, and which causes that dimness of the sun's light towards the margins which has been already mentioned? Does it buoy up and float those cloudy protuberances for some forty or fifty thousand miles above—not the real surface, but the outer photosphere of the sun? These are questions which, notwithstanding that they have been critically observed during the solar eclipses of 1842, 1851, 1858, and 1860, still remain undecided. Some *savans* hold that they are purely optical, caused by the sunlight striking the edges of the moon—the effects of that phenomenon in optics known by the name of *interference*, *i. e.* when light passes by any rough edge, and produces certain coloured fringes to the ray which is received on a screen. Are those ruddy prominences produced in this manner? In the first place, they are too sharply defined to have their origin in this way; in the second, they have been seen to *increase* in length as the moon passed *away* from them, and to decrease in dimensions as the moon passed towards them. This circumstance, which was confirmed by many observers, would seem to be conclusive of their being part of the real body of the sun, that the red flames are the faculæ, that the corona is the luminous atmosphere of the sun. But how are these strange rays of light produced in the corona? How are we to explain that they appeared on the left when total darkness commenced, and to the right when the moon was leaving the disc of the sun? The Astronomer Royal is of opinion that the atmosphere of the earth extends all the way to the moon, and that the light is reflected by this atmosphere. There are methods even of detecting whether such is the case, and in the present instance

it was found that the light from the corona was reflected light, and reflected too by the atmosphere of the earth. Another celebrated astronomer, at the same time that he believes in the existence of an atmosphere around the sun, still considers that the extraordinary rays of the corona are optical; and he has even been able to produce them artificially, by introducing a circular screen between the eye and the rays of light coming through an aperture in the walls of a dark chamber. But so many discrepancies exist between observers, that it is quite impossible to reconcile the accounts. Red prominences were seen by one observer which were quite invisible to his neighbour. Protuberances which were seen red at Miranda were seen white at Valencia. The rays of the corona at two different stations at the same moment were in different directions. Strangest of all, the decrease of the eastern protuberances, like the increase in the western, were more rapid than the moon's motion would allow of. There can be no doubt, too, but that the rays of the corona were seen curved, intermixed, and even tangential to the edge of the moon. We may state that the illustrations have not been selected by us on account of their eccentricity: both drawings have been made by very eminent observers—the one of the eclipse of 1858, by M. Liais; and that of 1860, by M. Feilitzch, who had previously observed the eclipse of 1851. The latter observer noticed that the corona was much brighter in the last eclipse than in that of 1851.*

The most trivial incidents during a total eclipse of the sun are watched with the greatest interest, particularly during those few moments when total darkness overspreads the earth. Having been stationed near Reynosa, in Spain, in company with Messrs. Buckingham and Wray, the writer was able to observe the last eclipse of 1860. First comes that gradual march of the moon over the sun, which latter, even when half obscured, is not sensibly diminished in lustre. Then the gradual waning of the crescent of the sun, until it is reduced to the merest thread of light, and then the obscurity begins. The thread of light is irregular, as we see by means of the telescope, and whilst we are looking at it (now invisible to the naked eye) we notice that it is broken up into fragments, brighter than stars and somewhat resembling electric sparks. Now, between the broken sparks, the first rays of the corona break out with the brilliancy of a glory; in another moment, the sun is completely hidden; the dark velvet surface of the moon is seen projected on the silvery corona, and all is in obscurity—a darkness not complete like that

* For remarkable differences of drawing we refer to the diagrams in the Astronomer Royal's Lecture as given in the *London Review* of September 21, 1861.

of night, yet something altogether different from twilight or the gloom of a rainy winter evening. The scenery around was illuminated, not only by the light of the corona, but by the more remarkable light which was seen in the southern horizon. For an altitude of some fifteen degrees, towering above, and in the direction of the plains of Castile, we saw the most glorious crimson and yellow tints colouring the sky and meeting the dark-blue clouds above in a rich purple. The effect was magical —almost similar to the earth illumined by a splendid aurora; or, rather, imagine passing from the brilliant sunshine into a Gothic cathedral, where the dim religious light enters through richly-coloured oriel and lancet windows—one may thus have a faint idea of the gloom—singular and terrible at the same time, which is produced by a solar eclipse. The hushed whispers of those around who pointed to some bright star or planet overhead, added to the solemnity of the scene and the sombre faces of the worshippers, put one as much in mind of the countenances of the witches round the caldron in "Macbeth" as of the witnesses of a great natural phenomenon. When the darkness was at the greatest, the wind moaned with a melancholy sound "le vent de l'éclipse," our neighbours call it, and did not serve to raise one's spirits. The pigeons rushed to their dovecot—butterflies fell down as if dead—a vulture seated on a rock on a neighbouring hill dropped as if shot—a group of goats formed into line and marched in the direction of home—the matutinal chants of chanticleer were intermingled with the sounds proceeding from the maternal cares of the feathered domestic tribes of the farmyard in which we were situated. Such effects of the darkness came under our own notice. And although we found that the boasted clearness of "le beau ciel de l'Espagne" was rather a myth and might be aptly compared to the famous "châteaux d'Espagne" (*Anglicè*, castles in the air), yet we did not think our journey from the banks of the Seine, across the Loire, the Garonne, and the Adour, altogether lost, even although we came across much unfavourable weather near the source of the Ebro; and met not only with snow to the depth of eight feet on the mountains (in the middle of July), but with solid mist and fog which could only be paralleled in November in London. Although we perfectly perceived the corona, yet it was too cloudy to detect the ruddy prominences; so that our evidence is negative in this respect, and it proves that the first-named was brighter than the latter, which some observers deny. The broken crescent, if not the Baily beads, were seen to great advantage by Messrs. Buckingham and Wray, as well as by the writer, and the extraordinary brushes of light from the corona, crooked and intermingling with each other, were likewise plainly visible to all the party. We have heard of Spaniard and Moor

crouching with terror during the darkness; but although we were in the midst of a crowd of the former nation, and a rural population too, we did not see it, and can scarcely believe it. As many discrepancies exist, however, between the statements of ordinary observers as between those who looked at the solar phenomena through a telescope. To one observer the darkness appeared to last for only two minutes (it was upwards of three); to another, such was the sense of oppressiveness, that the interval between the disappearance and reappearance of sunlight seemed to endure for two hours!

These are a few of the phenomena connected with the orb of day, the source of light and heat in our system of worlds.

LIGHT AND COLOUR.

BY ROBERT HUNT, F.R.S.

THE earliest truths, taught us in the oldest Book, are, that when darkness was upon the face of the deep, the Earth was without form and void; and that, after the creation of Light, the surface of this planet was speedily covered with organized forms, rejoicing in the fulness of life.

Man, through all time and in every country, has given expression to these truths. Light and Life—Darkness and Death—Light and Truth—Darkness and Falsehood, have constantly been associated in the human mind as relative terms. Every mythology has shadowed forth in some of its impersonations the connection of the Sun and its golden glories with all that is living and beautiful on the Earth. The Heaven of man has always been a realm of Light, and Hell a region of the deepest gloom. The Sun has, from the earliest indications of mental effort, been the object of religious contemplation amongst men, and through long periods of time, that orb has been the centre of their sincere, though mistaken, adoration. The highest efforts of pure thought which distinguished the refined philosophy of Greece leads but to this end, and Plato's sublime expression, GOD *is Light*, forms the sum, as it were, of the mental power of this refined people.

Advancing beyond this point, by the aids of inductive science, the moderns have been taught by their philosophers to regard the Sun as the source and centre of mighty Forces, upon which depend the great phenomena of terrestrial creation, and to see far beyond and above it the Omnipotent Creator.

The Sun is not to us an object of adoration, because by the increased penetrating power of our mental vision we are rendered conscious of agencies beyond the Sun, by which that orb with all its attendant worlds are regulated. Light is not a god to us, because we believe Light to be but one of the manifestations of Creative Wisdom. We burn no fires upon our hills as symbols of the sacred solar fires, because man has discovered that the vivifying forces of the sun-beam, are but indications of the transformation of matter taking place in obe-

dience to laws of the same order as those which produce Light and Heat on the Earth.

Although, however, we have ceased to adore the "Central Orb of Fire," we still regard the Sun with feelings of wonder. If our minds are freed from the thrall of superstitions by the development of some great truths, they are still struggling in the uncertainties of our imperfect knowledge, and seeking a deeper, a clearer insight into the vast phenomena which are opening upon our knowledge.

In the absence of the Sun there is night, and when the Sun's disc is obscured during an eclipse, notwithstanding the Light reflected from the sky, dark, unnatural shadows fall around us, and the colours of objects pass into neutral tints. These facts convince us that Light is derived from the Sun, and that the brilliant colours with which Nature is adorned are directly dependent upon luminous radiations.

The reader, it may be, sits in a room, the decorations of which are in brilliant colours, the furniture to match is of the richest dyes, and, let us suppose, the most brilliant flowers of the garden have been arranged around to add to the chromatic beauty. If the Light is gradually excluded, each object loses its colour, and eventually, if the darkening is proceeded with, all becomes black.

Another experiment is, however, necessary to carry conviction to the mind that the surfaces so richly tinctured are themselves colourless, and derive all their brilliancy from the physical condition by which some rays of Light are absorbed, while others are sent back to the eye.

We possess the power of producing flames which emit but one colour. Dry table-salt, if burnt in a gas-flame, or if it be mixed with spirits of wine and ignited, burns with a pure yellow light. If we make an experiment in our variedly-coloured room, excluding, of course, the daylight, every object which does not possess the power of sending back to the eye yellow rays, will, there being no other rays, appear of a dull neutral tone, or become absolutely black.

The brilliant red fire of pyrotechnic exhibitions is produced by strontian. If this salt is burnt, instead of the table-salt (*chloride of sodium*), all the yellows and greens disappear, and those surfaces only which reflect red are seen in colour.

The labours of the artist, the skill of the decorator, the technical skill of the dyer, have one end. They aim, each of them, at producing surfaces which shall act differently upon the incident rays, and thus produce different sensations on the organ of vision: those sensations which we call colour being dependent on vibrations communicated through the optic nerves to the brain; these luminous vibrations present-

ing a certain analogy,—but nothing more,—to the undulations of sound, which convey to the seat of sensation the impressions of musical harmony.

The hypothesis that Light is the result of vibrations, established by solar influence on some ethereal medium existing throughout planetary space, is now almost universally received. It is quite certain that by far the larger number of the phenomena of Light will admit of explanation, in a satisfactory manner, by this hypothesis only. At the same time, it must not be disguised that the most zealous advocate of the theory of luminous undulations, has failed to show that there is any support given to his views by the chemical phenomena of Light. It is not intended by this remark to suggest a doubt against a doctrine so ably supported; but it does appear necessary that there should be found in our philosophical records, at least, an attempt to show how chemical changes—photographic phenomena—are connected with undulatory motion.

That Light travels with immense velocity is evident to all. The flash of Light from a distant gun reaches the eye long before the sound of the explosion is communicated to the ear. To measure this velocity it is necessary that we should have the means of examining the passage of a ray of Light through vast distances, and this has been done by careful observations of the eclipses of the satellites of Jupiter.

Roemer, a Danish astronomer, in 1675, on comparing together observations of eclipses of these satellites during many successive years, observed that the eclipses when Jupiter was nearest to the Earth took place *too soon*, whereas when those two planets were at their greatest distance apart, the eclipses were always *too late*; that is, the eclipses of the moons by the planet were, according to the distance from the Earth, either sooner or later than by calculation they should have been. Speculating on the physical cause of this, Roemer was led to believe in a gradual, instead of an instant propagation of Light, and the velocity required to explain these differences between observation and calculation was 192,000 miles in every second of time. This has since received the fullest confirmation. Bradley, by his discovery of the *aberration* of light (the apparent displacement of a luminous point by the onward motion of any spot on the Earth's surface), has given us the means of proving that the error, if any exists, is an exceedingly small one: the most accurate determination giving 191,515 miles as the velocity of Light in a second. This is a speed which it is difficult to realize to the imagination. The greatest velocity which has been attained by locomotive engines, in some experimental trials on our railways, has been 100 miles within the hour. If we were to start at this speed from

the Earth and travel towards the Sun, and be enabled to maintain this speed through the entire space between us, we should require more than 108 years to complete the journey, and yet a ray of Light passes over the same space in seven minutes and a half.

If the reader will place himself in a dark room, of course objects are invisible to him; there is a negation of colour, because there is an absence of Light. Pierce the shutter with a needle, a thread of Light flows into the room, forms a round luminous spot of *white* Light on the floor; from this point radiation is established, and the eye begins to distinguish objects and to be sensible of colour. The phenomena of vision, and the phenomena of colour, are therefore proved to be dependent on the presence of the sun-beam.

If we take a triangular piece of glass (a prism), and place it so that the Sun-ray falls upon one of its angles, a new phenomenon results. A ray of Light, in passing from any medium into another of a different density, is bent out of its path, or undergoes refraction. The degrees of refraction are dependent upon the varying thickness of the mass, so that our wedge of glass presents a gradually thickening transparent medium to the rays. By this the Sun-beam, which enters the prism, of the most transparent whiteness, or colourless, leaves it a sheaf of rays intense in the brilliancy of their varied colours. The spectrum so formed, if received upon a screen, will be of a flame-like shape, and, commencing at that end where the ray is least bent, we have the following order in our chromatic scale: red, orange, yellow, green, blue, indigo, and violet. This image (which was represented in our last number, in connection with the dark lines by which it is crossed) has been called the Newtonian Spectrum, for to Newton we owe the first careful investigation of the phenomena. That philosopher determined the number of primary rays to be, as above enumerated, seven. Sir David Brewster, however, reduces the number to three: red, blue, and yellow; and from these he argues that all the infinite variety and beauty of colour which we see in nature must be derived by intercombination. Fig. 1 represents the principle of this; the three primary colours are in the corners of the equilateral triangle; green, orange, and violet, are produced by the combinations of the nearest two of these, and the neutral tint of the centre is the result of combining the three colours. This appears to require that a very prevalent error should be noticed. It is often stated that by combining pigments of the colours of the spectral rays, *white* is produced. Nothing can be further from the truth, as *black* is the result of the experiment.

It is undoubtedly true that if we recombine the rays of the

spectrum which have been separated by prismatic analysis, we produce white Light. But the statement that a disc painted in correct proportions of the primary colours will, if rapidly rotated, appear white to the eye, is far from correct. If a white circle is left in the centre of such a disc, as represented in Fig. 2, it will be seen that the combining colours, when in motion, produce, at the greatest velocity, a grey. It must be borne in mind that this is not the result of any combination of the colours, strictly speaking. The intensity of sensation produced by the different rays varies greatly; and when any many-coloured object is in rapid motion, those colours only which are the most intense, impress themselves on the retina; and from the persistence of the images so produced, the effect obtained is due only to some two or three of them.

The experiment is ever an interesting one; it may be studied with great advantage by means of Gorham's colour top, which philosophical toy becomes exceedingly instructive, when properly employed, in illustrating the phenomena due to the blending of either compound or primary colours in sets, and the persistence of one colour in close comparison with another.

To return to the spectrum. Beyond the seven bands of colour described by Newton, we may see some others which were unknown to him. Having, in our dark room, obtained a brilliant spectrum, if it is looked at through a piece of cobalt blue glass, a beautiful *crimson ray* is apparent below the red. If the spectrum is thrown on a piece of paper stained yellow by turmeric, a *lavender grey* ray becomes visible beyond the violet. If the spectrum is received upon a plate of glass stained of a canary yellow by uranium, a pale-green ray is seen beyond the lavender grey; and if we throw the spectral rays upon a solution of sulphate of quinine, we see celestial blue rays near the same spot. The rays last mentioned, have been called by Professor Stokes, who has fully investigated their phenomena, the fluorescent rays, from the circumstance of their being seen in great beauty in many specimens of fluor spar.

From this statement it would rather appear that the coloured rays are more, instead of less, than seven.

Sir David Brewster has been led, from his extensive investigations, to infer that the spectrum which we see is really three spectra overlapping each other; that the pure colours are seen at certain points of maximum effect, as red, yellow, and blue. Where the red and yellow blend, orange-coloured light is seen; and where the blue and yellow mix, green is visible. It happens, however, unfortunately that we cannot produce green by mixing a pure ray of blue Light and a pure ray of yellow Light. Under this difficulty many of the continental philosophers con-

FIG 4

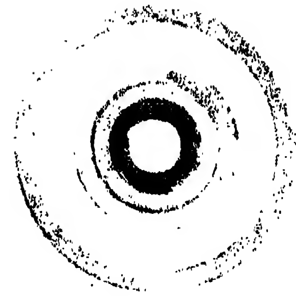


FIG 3

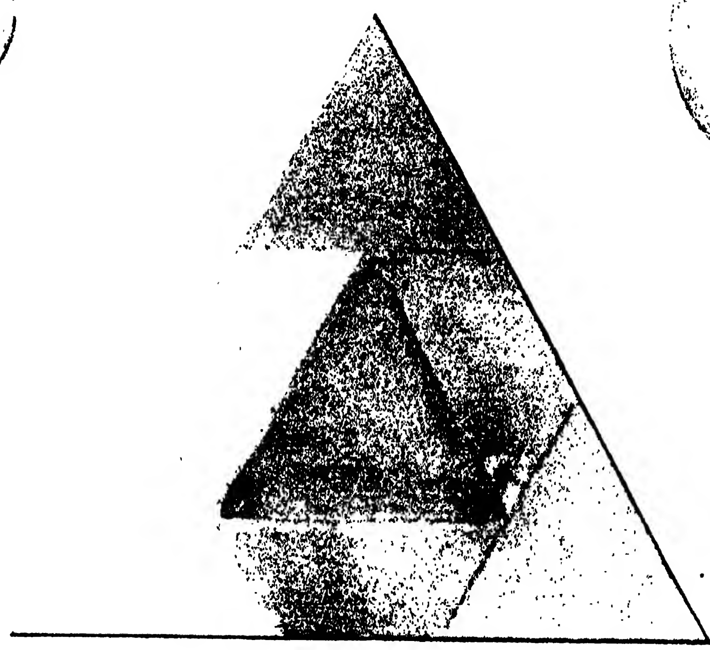


FIG 1

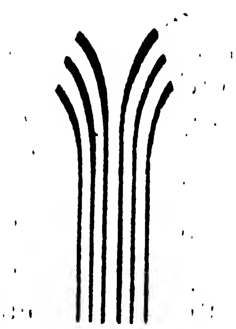


FIG 5

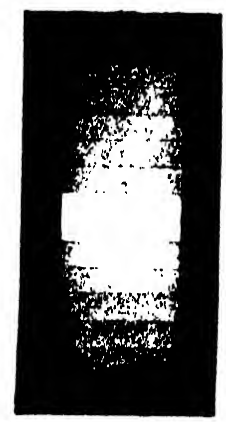


FIG 6

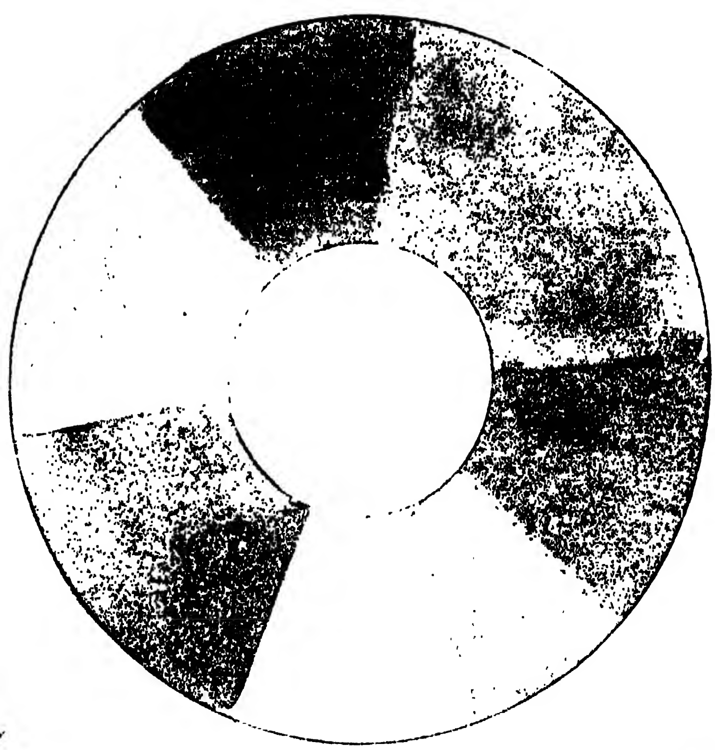


FIG. 2.

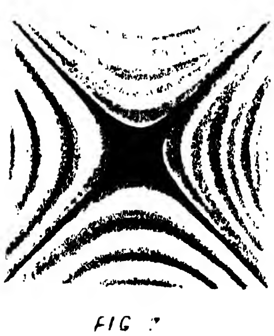


FIG 7

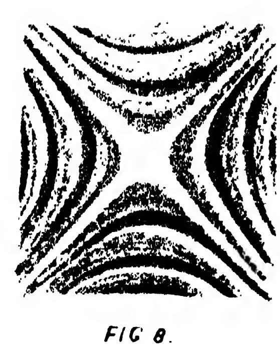


FIG 8.

LIGHT AND COLOUR.

sider green as a primary colour, consequently making their actual number four.

This is not the place, however, for discussing this delicate question; we have chiefly to prove that colour has no existence without Light. Another evidence of this is given in the colours of thin films. A soap bubble blown by a child, and floating in the sun-beam, becomes a study to the philosopher. If we mix soap with a solution of sugar in water, we may give considerable permanence to the filmy globe, and study all its beautiful changes, as the thickness of the film varies. A drop of colourless oil let fall upon water spreads out in a thin veil, and sends to the eye a glorious series of colours. Even films of air do the same thing. If a plano-convex lens is placed on a convex lens it is obvious that they can only touch at one point, and that films of air varying in thickness surround that point. The result of this is a system of circular coloured rings. They are of one set of colours when seen by reflection, and of another set when viewed by transmission. Looking *at* those rings, they will be in one condition, as shown in Fig. 3. Looking *through* them, they will appear as in Fig. 4, or complementary to the first. These remarkable colours vary with every variation in the thickness of the film of air.

Another illustration of the dependence of colour on Light is produced by passing the ray of light admitted through our pin-hole in the dark room, near the edge of any body. This effect is termed the inflexion of Light, or diffraction. If a short-focus lens be placed in the hole through which the Light is admitted, the effect is more intense. If a needle be held in this beam, its shadow will be found to be surrounded with three fringes: the first giving all the colours of the spectrum; the second, blue, yellow, and red; and the third fringe, pale blue, pale yellow, and pale red. It is impossible to represent these fringes by artificial colouring; but the beautiful curves formed are shown in Fig. 5. If the ray of Light be received on a glass rod blackened, and we look at it through a fine slit in a card, the appearance will be, as shown in Fig. 6—white light occupying the centre of the whole, and spectra separated by black lines extending on either side.

The colours of fibres and of grooved surfaces are easily seen. If we dust some hair-powder or lycopodium upon a glass plate, and look through it at a candle, the flame will appear surrounded by a halo. Fibres of silk or wool, spread out closely together, give rise to similar coloured rings. The colours of mother-of-pearl are due to the infinite number of fine grooves upon its surface. If we melt a little white wax, and pour this on the mother-of-pearl, it receives impressions of those fine grooves, and, if removed, when cold it will be as iridescent as the shell

itself. By drawing a series of exceedingly fine lines on steel, or any other metal, we may produce the same phenomena. Iris ornaments or Barton's buttons are obtained by cutting such fine lines on the surface of polished steel.

Space will allow only of our referring very briefly to the splendid chromatic phenomena dependent on the Polarization of Light. In some future number we may possibly be tempted to enter more at large into this fertile field of inquiry. To take the most simple form of illustration:—If we receive a ray of Light upon a plate of glass placed at an angle of about 56°, a portion of the ray is transmitted, and a portion is reflected. Now, if we place a blackened mirror, to receive the reflected ray, it will be found that the ray has undergone the change which we term *Polarization*. If a slice of sulphate of lime or mica be placed between the two and we observe its image in the black mirror, we shall see a series of colours such as are shown in Fig. 7; while, if this is turned round a quadrant of the circle, these are changed, and appear as represented in Fig. 8.

Brief and necessarily imperfect as this description of the phenomena of colour has been, it is hoped that the more important physical states upon which the production of colour depends will have been rendered intelligible.

All colour is dependent upon Light. Every variation in tint or hue is determined by the physical condition of the surface upon which the incident Light falls. Reflection, absorption, refraction, diffraction, and polarization, are all engaged in producing that exquisite display which adorns the fields of Nature, and which is so effective within the domains of art.

THE GREAT EXHIBITION BUILDINGS.

BY WILLIAM FAIRBAIRN, LL.D., F.R.S., ETC., PRESIDENT OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, ETC.

THE introduction of the use of iron in buildings has been a great desideratum for the last twenty years. For nearly a century, iron has been employed in the construction of steam-engines and machinery; and as improvements have from time to time been made in its manufacture, and confidence has been gained through experience in its use, it has gradually usurped the place of other materials in millwork, in shipbuilding, and for bridges. But its application to dwelling-houses and public buildings has been retarded by a want of the requisite knowledge on the part of architects and builders, and a determination in many quarters to resist its introduction as an innovation upon the good old practice of employing brick, stone, and timber, for such purposes.

To ensure economy and success in the introduction of iron as a building material, the architect should make himself acquainted with its properties in its cast and malleable state, and he must commit to memory certain facts which bear upon the comparative resisting powers of these two materials under various kinds of strain.

An example of the knowledge which is indispensable to architects and builders desirous to be considered proficient, will be found in the following data:—

	Tensile Strength per square inch in lbs.	Compressive Strength per square inch in lbs.	Transverse Strength per square inch in lbs.
Cast Iron	16,500	112,000	40,000
Wrought Iron ...	51,000	38,000	42,000

Thus, it will be observed, that whilst the *tensile* strength of wrought-iron is three times as great as that of the cast metal, its resistance to crushing is only about one-third as great; and these facts point to the effective and economical employment of wrought-iron as ties, and in similar cases where tensile forces have to be resisted, and to the use of cast-iron for columns and framework, where the desideratum is to withstand the power of compression.

Again, the architect must be aware of the different arrange-

ments necessitated by the varying properties of these materials. A cast-iron beam, for example, should have its bottom flanch * six times the area of the top one, or, in practice, at least four times, to suit the convenience of casting.

On beams of *wrought*-iron, on the contrary, a different arrangement is necessary, the area of the top flanch requiring to be nearly double that of the bottom,—to attain a maximum power of resistance. In large wrought-iron girders for bridges, the construction is again modified by the introduction of tubes or cells in the upper flanch, as in the Conway and Britannia bridges, when the areas should be proportioned in the ratio of 11 to 12. Again, it should be understood, that the strengths of girders of similar proportions increase as the squares of the span, whilst their weights increase as the cubes of the span.

With these preliminary observations, it may be interesting to glance cursorily at the history of the application of iron to constructive purposes down to the present time, when it is most strikingly exemplified in the works in progress at South Kensington.

The exact time when cast-iron came into use appears to be very uncertain, although for the casting of cannon and other purposes it has been employed from an early date. It was not, however, till 1794 that John Rennie applied it successfully to millwork, in the machinery of the Albion Mills, Southwark. It was employed for bridges as early as 1777, by Mr. Pritchard at Colebrook Dale.

The first notice we have of its application to buildings, was the use of cast-iron beams at Messrs. Philips and Lees's cotton mill in Salford, in 1801. These beams, extending from wall to wall, were supported in the middle by cast-iron columns and carried brick arches to form the floors, which were consequently fireproof. For half a century this same principle of construction has been successfully followed and applied to nearly the whole of the factories of Lancashire and Yorkshire.

In the use of cast-iron there is, however, a hidden source of danger, arising from flaws in the castings, want of proportion, &c., and several serious and fatal accidents have resulted from this cause, as well as from ignorance of the properties of the material. Hence we earnestly recommend the more extensive application of wrought-iron in every case where tensile strains have to be resisted. The breakage of cast-iron beams not only involves the destruction of property, but, what is far more serious, a great sacrifice of life, of which the accident at the Hartley Colliery is a fearful example; and this

* The flange or flanch is the projecting ridge at either side of the beam.

question is, we believe, at the present moment engaging the serious attention of the Legislature.

The first house entirely built of iron was, we believe, constructed by the writer's firm, at Millwall, London, in the year 1840. It comprised a flour-mill, three stories high, with cast-iron pilasters at the corners and sides, with intermediate plates of sheet-iron. The interior was plastered upon wire gauze, leaving a space of three inches between the plaster and the external plates, to secure uniformity of temperature within. This mill was constructed in sections, and shipped, along with its steam-engine and machinery, to Constantinople, where it still exists. In subsequent years some few houses were constructed of corrugated iron plates, and the discovery of the gold-mines in California and Australia created a considerable demand for these, so that hundreds of houses, and even churches, warehouses, &c., were despatched to these remote countries.

Such was the history of our iron constructions up to the year of the Great Exhibition of 1851, when a new era in the application of iron dawned upon us, taking its rise in a rude sketch executed by Sir Joseph Paxton whilst travelling from Chatsworth to London. It is well known with what success this unique structure of glass and iron, so happily conceived, was ultimately erected. This was the first colossal building of iron; next followed the Crystal Palace at Sydenham, and subsequently the Art Treasures Exhibition of Manchester and the Exhibition at Paris, of the same material.

These structures are, however, likely to be eclipsed by the gigantic buildings of the same character in progress at South Kensington; and it is in reference to these that we shall now attempt, without entering into a scientific analysis, to give some reliable data which may afford to our readers a clear perception of their magnitude, and of the purposes for which they are destined.

The deep interest which the lamented Prince Consort always took in every movement calculated to promote the education and improve the condition of the people of these islands is proverbial; and his increasing desire to raise the standard of taste in the industrial as well as the fine arts is so well known, that his premature removal has been universally regarded as a national calamity. It is no wonder, therefore, that the nation looks forward with some anxiety and with great hope to the success of the forthcoming Exhibition, as a kind of memento of the services and encouragement which have been lost to it through that heavy bereavement with which it has been visited, in common with her Majesty.

In the building itself, which covers an area of nearly twenty-

five acres, will be found articles of every possible description, and her Majesty's Commissioners have spared neither labour nor expense in making ample provision for the extraordinary demands that have been made upon them. It was found, however, that seven times the space provided, gigantic as that is, would be required to meet all the demands of the exhibitors, and the Commissioners have been compelled reluctantly to cut down the allotments, in many cases, to one-third or one-fourth of what was required by exhibitors.

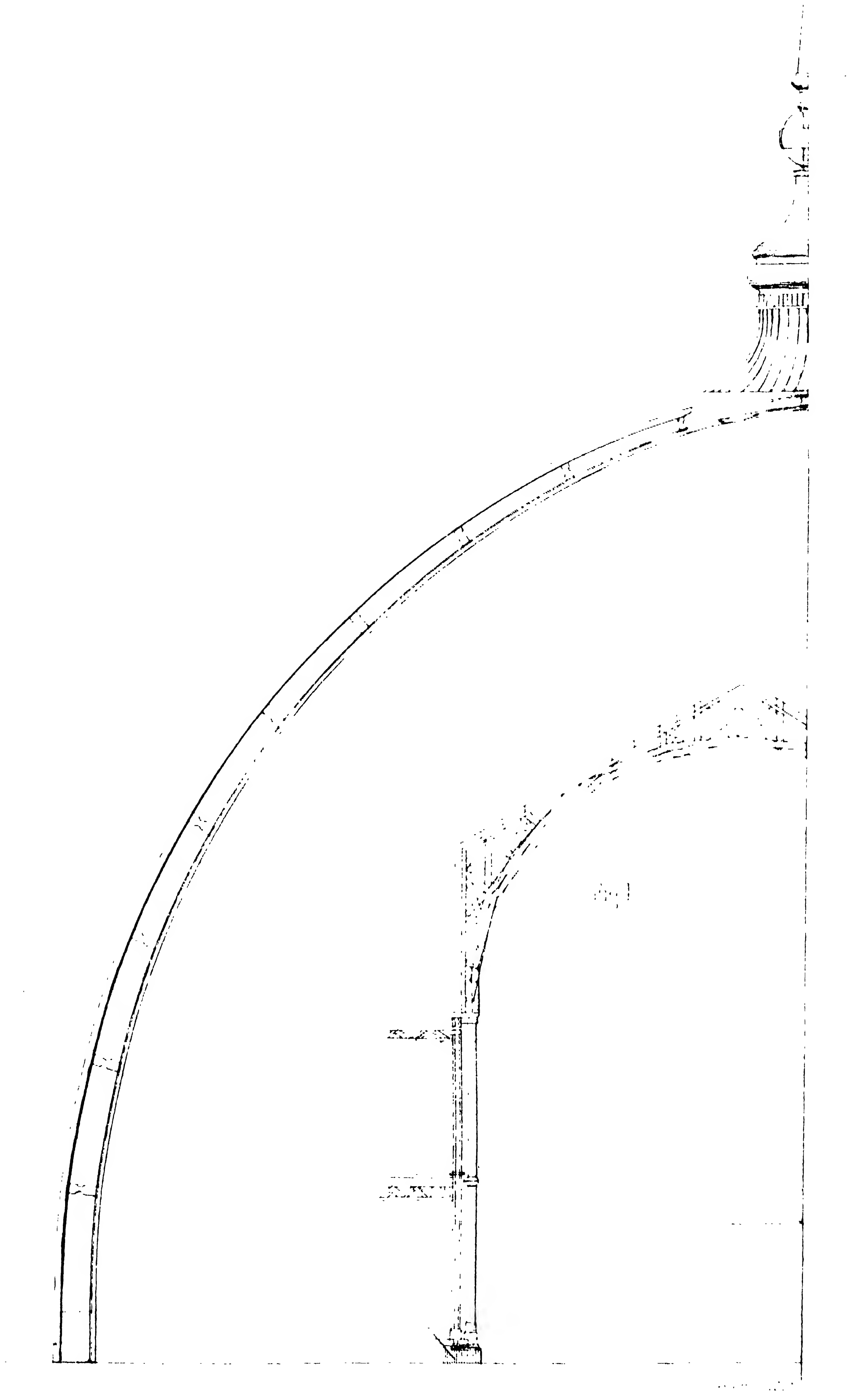
The most prominent feature of the original design prepared by Captain Fowke was a Great Hall, 500 feet long, 250 feet wide, and 210 feet high, behind the principal entrance on the south side. The cost of the building, as then estimated, was £590,000, which exceeded the means that the Commissioners could reasonably expect to have placed at their disposal, and the Great Hall was, therefore, abandoned. The general plan of the present design consists of a great Nave with Transepts at each end, whilst at the intersection of these are the two immense domes, which form the chief features of the east and west fronts. The nave is 800 feet long, 85 feet wide, and 100 feet high, or four feet less than the great central transept of the Exhibition of 1851. It is supported by coupled cast-iron columns, fifty feet high, and at distances of twenty-five feet apart, on which rest the great arched ribs of the roof and the horizontal girders of the galleries, as shown in Plate XVIII., Fig. 1.

The Picture Galleries, the finest and most extensive in Europe, are permanent buildings of brick, 50 feet wide and nearly 1,200 feet long. They extend the whole length of the Exhibition facing the Cromwell-road, and form a magnificent series of apartments. The principal entrance to these spacious galleries is through a hall, 150 feet long by 110 feet wide, leading to the inner courts, and also to the stairs which conduct to the galleries above and diverge from the entrance on either side.

In the designs for the galleries great care was taken in regard to light and ventilation, so essential to the inspection and preservation of pictures. On ascending the stairs, the visitor enters a vestibule of the same proportions as the hall below, and from this point is obtained an unbroken vista through the whole extent of the gallery; and it is difficult to conceive a more imposing effect than the noble proportions of the galleries on both sides.

An eminent writer, in describing it, states that—

"On entering the front, on either side the visitor will find himself in a spacious hall, 325 feet long, 50 feet wide, and 43 feet high. Passing through this, he will enter one of the wing towers, which forms a room 52 by 45 feet, and 66 feet high; he will then enter another room, 75 feet long and of the same width and height as the first, from which he will pass into the end



tower, where he will have an uninterrupted view of the whole main gallery. The interior decoration of these rooms is very simple, and may be briefly described as a plain cove extending to each side of the skylight, and resting on a moulded cornice."

Thorough ventilation is amply provided by the admission of air through apertures at the level of the floor, and allowing the vitiated air to escape through louvres* in the skylights above. The lighting of the gallery is very successful, and the important point gained is an equal distribution of light, so as to prevent any reflection of rays from the picture to the eyes of the spectator. This has been successfully accomplished, and there is every reason to believe that in any position where the spectator may stand, the pictures will be seen with the best possible effect.

The galleries, which extend along both sides of the nave and transept, are supported by cast-iron girders, which rest on the double columns, which ascend to a height of fifty feet from the floor, and from which spring the principal arches of both nave and transept. These girders are at right angles with the line of the nave and transepts, and rest on single columns twenty-five feet high under the centre of the fifty-feet wide galleries, and on those which surround the spacious courts on both sides of the nave. They are formed of a series of equilateral triangles, which unite the lower and upper flanges, and are calculated to support more than four times the load that ever can be brought upon them by a crowd of people closely packed. Between the transverse cast-iron girders the joists and flooring are supported by wooden beams trussed with iron rods; and on these and the front iron beams (to which is attached handsome railing on both sides surrounding the nave and courts), are placed the joists and boarding, forming an extent of upper-gallery accommodation equal to *one mile and a half in length*, and varying from fifty to twenty-five feet wide.

The upper girders which support the flat roof, covered with felt and zinc, are of lighter construction than those below, but of sufficient power to resist four times the weight to which they can ever be subjected. The level of the flooring is five feet below that of the surrounding streets; and the object of thus sinking the floors is to obtain a more imposing view of the building as the visitor enters from the domes at each end. He will, therefore, ascend two steps to a large platform or dais at each entrance, and from thence descend, by a flight of steps eighty feet wide, into the nave or transepts on three sides. There are four large courts: two of them 250 feet by 200 feet; two more, 250 feet by 86 feet wide; and two central courts,

* Louvre, lover, or loover, from the French word *l'ouvert*—the opening.

one 150 feet square, and the other 150 feet by 86 feet wide. All these are 50 feet high, covered with glass, and lighted from above. They are the only parts which resemble the Crystal Palace.

One important feature in which the Exhibition of 1862 differs from that of 1851, is the Refreshment-rooms and Arcades. They are built of brick, and overlook the whole of the Horticultural Gardens. Unlike its predecessor of 1851, where the refreshments were confined to biscuits, soda-water, and buns, those of the present Exhibition will be on a large scale, every description of refreshment being supplied in spacious dining-rooms 300 feet long by 75 feet wide; and the arcades on each side will be collectively about 1,500 feet in length and 25 feet in width.

The Annexe or machinery compartment, which extends along the west side of the Horticultural Gardens, is composed of four spaces, each 1,000 feet long and 50 feet wide, covering an area of 50,000 square feet. The whole of these constructions comprises a "ridge-and-valley" roof, composed of a very cheap material, and of very simple construction, namely, deal boards, nailed together in the form of arches, which spring from vertical standards of two 2½-inch planks nailed together to a height of 28 feet. These, again, support the gutter plank, where the feet of the rafters terminate, a little below the intrados of the curved arch. The roof frames are boards nailed together, and so disposed that the weight comes direct on their edges. The lower part of the roof is covered with boards and felt, and the upper part is glazed with skylights, having bearers for ventilation throughout the whole length of the three divisions.

This department of the Exhibition will be devoted entirely to machinery in motion; and, in order to give every facility to exhibitors, a large supply of steam from six 50-horse boilers, placed at the north-west corner of the Horticultural Gardens, will be conveyed in pipes laid in a tunnel the whole length from north to south, at the cost of the Commissioners. Provision is also made, by the introduction of large wrought-iron pipes, for carrying the exhausted steam clear of the buildings, from the numerous engines supplied by the exhibitors; and these again, with the necessary shut-off valves, will constitute the motive power to be employed in driving every description of machinery submitted for public inspection. In addition to the steam required for these purposes, upwards of 2,300 feet of 2½-inch polished shafting will be extended, at a height of 10 feet from the floor, for the accommodation of the exhibitors. The shafting will be supported on neat cast-iron columns, extending at convenient distances in lines along the middle of the different divisions, and of suitable lengths calculated to meet the requirements of the exhibitors and give motion

to the different machines. In fact, the department of machinery in motion being entirely separated from the other parts of the Exhibition, there will be no risk of injury to any of the more delicate articles of manufacture, nor to those instruments which require to be kept dry and free from an atmosphere charged with vapour where steam machinery is employed.

From this description, it will be seen that the machinery department will of itself be a distinct and separate exhibition; probably the most perfect of its kind ever brought before the public. It will contain some of the most ingenious mechanical contrivances of this inventive age, and, from its extent, will furnish a collection of machines employed in almost every branch of manufacture, not only in this country, but from every part of Europe and America. In this World's Fair will be exhibited competitive machinery of every description, from the most ponderous steam-engines to the delicate lace and sewing machines. How suggestive of progress to the mechanic and artizan, and how interesting, will be the comparison of these unique operations when presented to the eye of every considerate and reflecting spectator! This combination of talent and the whole cunningly devised machinery of the useful arts being employed on their respective operations, is no common sight; and it is only in this deeply interesting department that we shall learn to admire and fully to appreciate the value of the inventive powers of the present age, and the purposes to which they are applied in the useful and the industrial arts.

Exclusive of the Annexe for machinery, there is another of the same character ranging along the eastern side of the Horticultural Gardens, for the reception of agricultural implements and the larger specimens of metallurgy, mineralogy, and geology, and of heavy machines which do not require motion. To the farmer, agriculturist, and rural population this portion of the Exhibition will afford examples of every improvement that has taken place for the last twenty years; and the young agriculturist need only employ his observation in order to make himself master of what is being done to attain still greater perfection in the tillage and the increased production of the soil. Here will be found every variety of hand-plough, scarifier, and grubber; and here, also, will be exhibited various descriptions of steam-ploughs, reaping-machines, straw-cutters, &c., &c.; and the most casual observer will not fail to derive benefit from such a display of the great and important features which, in machinery alone, have changed the face of the country, and almost quadrupled the produce of the land.

Our limited space will not admit of further description; but in closing this somewhat imperfect account of the Great International Exhibition Buildings, it may be proper to advert to the security of the whole structure, which is due to the excellent designs of Captain Fowke, placed in the hands of the contractors, Messrs. Kelk, and Charles and Thomas Lucas Brothers, for execution. To these gentlemen every praise is due for the liberal and efficient manner in which they have performed their contract. The whole of the responsibility for the execution of the works rested on them and their engineer, Mr. Meeson, C.E., who prepared the working drawings to be submitted to a Building Committee, consisting of the Earl of Shelburne, the writer, and Mr. W. Baker, who undertook to act for the Commissioners in conjunction with Captain Fowke and the contractors above named.

The general features of these large structures have no claim, according to the opinions of some persons, to architectural design, but they are admirably adapted to meet the requirements of the Exhibition; and the long vista of the nave, with the domes and transepts at each of the east and west entrances, will convey to the spectator a sense of perfect harmony as regards altitude, magnitude, and general effect, seldom to be met with in public buildings. Independently, however, of architectural considerations and an imposing exterior, the great and important aim of the Building Committee was to see that every part should be made secure, and that no danger could possibly arise through a want of due proportion in the different parts, and of the needful strength in everything that might affect the public safety. On the part of the contractors every alteration and all the wishes of the architect and committee have been cheerfully and liberally conceded, and the result is the following letter, confirmatory of the trials and experimental facts arrived at in testing the resisting powers of the different floors and girders, and the great domes covering the points of intersection of the nave and transepts:—

"To the Commissioners of the International Exhibition.

"My Lords and Gentlemen,—Feeling that it would be a source of satisfaction to the Commissioners, as well as to ourselves, as members of the Building Committee, and also a due precaution for the public safety, that the gallery and other floors of the International Exhibition Building, at South Kensington, should be thoroughly proved, we undertook a series of experiments on Monday last.

"We have to report that, in carrying out these experiments, the various floors and stairs were put to a more severe test than they would be subjected to with the largest number of people that could possibly be assembled upon

them at any time during the Exhibition. The results of these experiments fully bear out our calculations on the strength of the different parts of the structure, and we feel perfectly satisfied as to the stability of the building for the purpose for which it was intended.

"The two large domes, in the strength of which we have taken great interest, were eased from their temporary support last week, and no observable settlement took place.

"The following are the particulars of the tests:—The first caused a large body of men, about 400 in number, to be closely packed upon a space 25 feet by 25 feet, on one bay of flooring; we then moved them in step, and afterwards made them run over the different galleries, and down each staircase; at the same time we caused the deflections of the girders carrying these floors to be carefully noted at several places, and had the satisfaction of finding that in each case the deflections were very nearly the same, thus exhibiting a remarkable uniformity in the construction. The cast-iron girders, with 25 feet bearings, deflected only one-eighth of an inch at the centre, and the timber-trussed beams of the same bearing placed between these girders deflected half an inch at the centre. In every instance the girders and trusses recovered their original position immediately on the removal of the load.

"We are, my Lords and Gentlemen, yours faithfully,

"WM. FAIRBAIRN, }
"WILLIAM BAKER, } C.E.

"London, Feb. 13."

Before the dimensions, forms, and conditions of the columns, girders, trussed beams, and rafters had been decided upon, a long series of preliminary experiments were carried on, and it was not until the Building Committee and Captain Fowke were fully satisfied as to the security of every part, that the building was allowed to proceed. Not satisfied with these early precautions, the Building Committee resorted to the final and still more severe tests of impact and concussion as produced by marching the large body of men linked together over stairs and galleries at quick and afterwards at "double step," stamping hard on every part of the bays of 25 feet square. All these precautions have been taken to secure the public safety when placed under every conceivable condition in which they can be loaded by a moving mass of people.

Amongst the most prominent features of these buildings, and those that have created anxious consideration on the part of the Building Committee and the engineer, Mr. Meeson, are the great Domes. These large constructions (designed on a scale greater than anything of the kind had ever been done before) were carefully considered, in order to be within the limits of the estimates, and at the same time to ensure ample stability in the structures. They were originally calculated to sustain a force of 40 lb. per square foot, if such a force could ever be

applied by the most powerful tempest ever known in this country, which, however, seldom exceeds 26 lb. to the square foot.

On the whole, therefore, we are justified in coming to the conclusion that the buildings are not only secure, in so far as regards the public, but they are admirably adapted for the purposes intended; and it is our sincere wish that every other feature in the Exhibition may prove satisfactory to the Commissioners,—that their object may be fully realized in a brilliant success!

ON THE RELATION OF SCIENCE TO ELECTRO-PLATE MANUFACTURES.

BY GEORGE GORE.

PART I.

LITTLE did Gay Lussac think when he discovered cyanogen, in the year 1815, the great influence which that substance would have upon the comforts and luxuries of every-day life. Prussian blue, the substance with which laundresses colour linen, and which is composed of cyanogen and iron, was, it is true, known as long ago as the year 1704, when it was discovered by Diesbach and Dippel, in Berlin; but that this substance contained cyanogen was not known until Gay Lussac discovered it.

All experimental knowledge generally passes through three stages,—viz., discovery, invention, and practical daily working: a philosopher discovers some new fact or principle in nature; an inventor applies it to some useful purpose; and a man of business brings the invention before the public, and continues it in daily use.

Suppose that Gay Lussac had not discovered cyanide of potassium, and that it had never been discovered, it is highly probable that the manufacturing returns of Birmingham, Sheffield, and other places in which electro-plating is conducted, would be much less in amount at the present time than they are, simply because there is no other known substance with which the electro-plating of base metals with gold and silver can be satisfactorily effected.

The base of every article which is coated with a thin film of silver for domestic purposes by electro-plating, consists of an alloy of three metals—copper, zinc, and nickel; this substance, commonly called nickel silver or German silver, is chosen for this purpose, because it possesses a white colour nearly allied to that of real silver; and when the outer coating of noble metal is worn away by use, the exposed baser portions do not present the unseemly appearance that they would if a metal or alloy of another colour, such as copper or brass, had been used.

Nickel was discovered by Cronstedt in the year 1751, and

is now a metal of considerable importance in the towns of Birmingham and Sheffield; the galvanic battery was discovered by Volta in 1800, and magneto-electricity by Faraday about the year 1830. Without the discovery of nickel we should have had no nickel refineries, nor German silver manufactories; and without galvanic and magneto-electricity the extensive trade of electro-plating would never have sprung up, and the manufacture of galvanic batteries, telegraphic instruments, and especially of the immense quantities of telegraph wire now consumed, would never have existed.

These and other kindred scientific truths having become common-place facts of everyday life, we are apt to think that abstract science has had but little to do with their production, and we are thus unconsciously led to undervalue the importance of abstract scientific investigation.

It is true that many processes of manufacture have not been consequences of abstract scientific discovery, that they originally resulted from alterations made in the rudest artistic appliances, and that they have been directed and improved by the results of experience. For ages past we have been deriving the benefit of scientific principles without a knowledge of their existence; we have trodden in the beaten path of experience, ignorant of the truth that we were acting in unison with fixed and certain laws. Numerous arts and processes were in extensive operation long before the principles involved in them were at all understood; the arts of enamelling and of iron-smelting were known hundreds of years before we were acquainted with the principles of chemistry. In some instances the recorded results of daily experience in practical matters, tabulated and studied, have led to the discovery of scientific laws, but this is merely the making use of our ordinary experience for the advancement of knowledge, instead of making *special experiments* for the purpose.

It is also true that many discoveries remain a long time before they are practically and extensively applied, that some made long ago have not yet found a practical use, and persons of superficial minds, therefore, frequently inquire, "what is their use?" Their use is to assist in the development of other discoveries, and to be ready at the command of the inventor, who applies them to useful purposes. Of what use were the various abstract investigations upon specific heat, latent heat, the tension of vapours, the properties of water, the mechanical effect of heat, &c., by Black and others, but to be ready for the illustrious Watt to apply in the steam-engine? Of what use was the discovery of atmospheric electricity by Franklin, but to lead to the preservation of human life by means of lightning conductors?

It is true that many things which have appeared very promising in theory or in experiment have failed altogether in practice, but why is this? It is not that the principles of nature existed in the one case, and did not exist in the other, but that we have imperfectly understood them; that from some unforeseen circumstances we have been unable to apply them, or that we have indolently abandoned them without sufficient or proper trial.

In many cases we are unable to obtain the same conditions of success upon the large scale that we have upon the small scale; if we melt some brass in a crucible, and cover it with a layer of borax, and dip a piece of perfectly clean iron into it, the iron will receive an adhesive metallic coating; but if we attempt to coat very bulky articles, such as sheets of iron, by this process we fail, because no vessel will withstand the heat and great weight of the melted metal.

In other cases a process fails because of its too great expense; many attempts have been made to supersede steam as a motive power by means of electro-magnetism, and engines driven by that force have been constructed of five or ten-horse power; but the cost of driving them has been found to be at least ten times the amount of that of a steam-engine of equal strength.

And in other cases we fail because we attempt *at once* to carry out upon a large scale that which has only been the subject of a small experiment, instead of enlarging the process by small degrees, and adapting the apparatus, the materials, and its treatment, to the size of the operation.

That which appears very simple in the hands of an experimentalist almost invariably becomes much more complex when carried into practice in a manufactory, simply because there is then a greater number of conditions to be fulfilled. Electro-plating a piece of steel with silver is to a chemist a very simple matter, because it is of no importance to *him* whether the silver adheres firmly, is of a good colour, or is deposited at a certain cost; but with a *manufacturer*, unless *all* these conditions are fulfilled, the process is a failure.

No towns have perhaps benefited more by scientific discovery and its application to trade, than Birmingham and Sheffield,—the former in particular. The great bulk of the articles manufactured there being composed of metal, are produced and ornamented by mechanical and chemical processes, and therefore offer peculiar advantages for the application of mechanical and chemical knowledge.

Many manufacturers seem to think that because their operations are so completely routine, and have been handed down to them by their predecessors in nearly their present state, they are not at all indebted to science; but there is no

manufacture, especially amongst metals, which does not continually involve scientific knowledge.

Not only has science benefited manufacturers, but also operatives, because the extension of science to manufacturing purposes has compelled them to make themselves acquainted with intellectual subjects. Instead of remaining mere machines, mechanically performing the work set before them, they are obliged to exercise the faculties of observation and judgment in watching the results and directing the action of mechanical, physical, and chemical forces. Instead of following the blind path of experience, using unknown forces to accomplish some definite result, they pursue their labours with the aid of known and certain laws.

No man has more occasion to bless the introduction of the steam-engine, machinery, the galvanic battery, and science in general, than the working mechanic, because it has mitigated his physical toil by giving him the duty of simply directing the labour instead of actually performing it: whilst it has deprived him of one kind of employment it has provided him with something better. But a few years ago the operatives in the silver-plating trade had to lay the silver on the articles with their hands and the aid of a soldering-iron; *now*, they have simply to set their batteries in action, and watch the electricity doing it for them. In a similar manner the working engineer at his metal-turning lathe has merely to direct the action of his tools whilst the steam-engine performs the heavy labour of turning.

In the present period of scientific progress, when the attention of men of business is so frequently attracted to some new invention or discovery which appears likely, if not to supersede their particular occupation, at least to have some influence upon it, it is the interest of every such person to watch the progress of science and to seize it for his own advantage, instead of allowing others to do so, and thereby divert his trade into other channels.

No art nor manufacture is so perfect as to be exempt from the influence of discoveries and inventions, and no man can produce so perfect an article, but that by the aid of science a better may be produced.

In what consists the great success of applying science to trade?—simply the influence of demonstrable truth. We know that if we have once discovered all the laws or conditions of some improved process or result in a manufacture, the reproduction of exactly the same conditions will hereafter enable us to invariably produce the same result. In this respect science differs from empiricism, for in empirically working a process we are ignorant of the condition or laws which are operating, whilst with a scientific knowledge we understand those laws,

and can direct them to our particular purposes. In the process of electro-plating, we understand the laws of the phenomena, and can direct them so as to obtain silver of a hard or soft quality, brittle or tough, crystalline silver, &c., according to our pleasure; but if we had only an empirical knowledge of the subject, we could not thus vary the process.

The great success of coating articles with silver by the electro process depends in a very large measure upon the demonstrable fact that alkaline cyanides have a strong affinity for noble metals, and but little affinity for base metals; no other substance possesses this quality, or at least in so eminent a degree. In proof of this fact, I have twisted together two similar-sized and clean pieces of very thin wire, the one piece being gold and the other iron, and immersed the double wire in a solution of cyanide of potassium; in about six weeks the so-called "indestructible" metal, gold, was all corroded and dissolved, whilst the base and "destructible" metal, iron, was as bright and perfect as ever. Further, if two pieces of wire, the one being of gold and the other of iron, are connected with the ends of a galvanometer, and their extremities immersed in a solution of cyanide of potassium, or other alkaline cyanide, the noble metal will be found to be electro-positive to the iron; and a galvanic battery of weak power might even be constructed of those three elements, which would present the singular anomaly of generating an electric current *in an opposite direction* to that in all other cases obtained.

So great a resistance has iron, and so strong an affinity has silver to be dissolved by a solution of cyanide of potassium, that if a current of electricity is simultaneously sent through both into that liquid, the electricity will pass freely as long as there is a portion of the silver remaining, and the silver will dissolve rapidly; but as soon as all the silver has dissolved the current will be nearly stopped, and the iron, instead of dissolving, will liberate bubbles of gas.

This is precisely the condition that was required for the success of electro-plating, viz., a liquid which should not corrode (as *acid* liquids do) the articles of base metal immersed in it, and should easily dissolve and retain in solution the noble metals with which the articles were to be coated, and at the same time conduct electricity readily, and not lose those qualities by exposure to atmospheric air; alkaline cyanides are the only known liquids that fulfil all these conditions.

ARTIFICIAL PRECIOUS STONES.

BY W. G. HOWGRAVE.

SINCE Sir Humphrey Davy first discovered the diamond to be pure carbon, unmixed with any other substance, various attempts have been made by chemists to produce it, and other precious stones, by artificial means; and it may not be uninteresting to glance at some of these essays, and to see how far they have been attended with success.

But little progress has as yet been made towards the discovery of the means of imitating the natural diamond, men of science having hitherto been baffled in all their efforts to find a substance capable of dissolving carbon, the chief constituent of that crystal; and indeed, until Despretz succeeded, by the agency of electricity, in actually producing minute diamonds, the manufacture of this precious stone seemed as chimerical as that of the philosopher's stone, so perseveringly sought after by the ancient alchemists. Despretz found, that by passing a powerful galvanic current through a point of charcoal over which a platinum wire was suspended, the charcoal was volatilized and deposited on the wire in the form of minute crystals, which, on examination under the microscope, proved to be true diamonds. Since this discovery no further advance has been made towards the solution of this interesting problem.

The search after the diamond having proved so unsatisfactory in its results, attention was directed to a class of stones almost as simple in their composition going under the generic name of *corundum*. In order to understand the experiments that were made, and the difficulties attending them, it is necessary that a clear idea should be obtained of the composition and distinctive characteristics of the stones belonging to this class. I will therefore, in as few words as possible, give a description of their nature and properties.

The ruby, sapphire, oriental topaz, and several other precious stones, are all merely coloured varieties of a mineral called corundum, or white sapphire, the composition of which was stated by Chenevix to be alumina, mixed with a small proportion of silica and oxide of iron. Dr. Thomas Muir and

others proved, however, that it was pure alumina, the silica found by Chenevix being abraded from the substance in which the stones were imbedded. All the varieties of corundum crystallize in six-sided prisms, and have the curious property of double refraction; *i. e.*, causing everything that is looked at through them to appear double. Alumina, the oxide of the metal aluminium now coming into such frequent use in the manufacture of articles of jewellery, &c., was, until the invention of the oxyhydrogen blowpipe, supposed to be, like carbon, infusible by any degree of heat. In 1837, however, M. Gaudin, who had given much attention to the effects produced by this then newly-invented means of generating heat on various metallic oxides formerly thought unsusceptible of fusion, attempted with some success to convert, by its aid, the apparently infusible alumina into crystals similar to the ruby and the other oriental stones. He proceeded by submitting to the action of the blowpipe a mixture of alum (sulphate of alumina and of potash) and chromate of potash, which he placed in a cavity of animal charcoal. In this manner he obtained small portions of melted alumina, having the colour and hardness of the ruby, but which could be easily distinguished from it by their imperfect transparence, and by their not possessing the property of double refraction. All subsequent attempts to obtain crystals of alumina, coloured like the precious oriental stones, have failed in a similar manner; and this has been accounted for by the discovery only lately that the colour of these stones is not due to a metallic oxide, as had been always supposed, but to the presence of some organic colouring matter. The application of this discovery may bring us nearer than we have ever yet been to the invention of a mode of producing artificially these rare gems.

The next step in this direction was made by the manager of a manufactory of Sevres porcelain, named Ebelmen, who, ten years after M. Gaudin's experiments, found out a way of obtaining crystals of corundum, but of such minute proportions as to be of no practical use. He first discovered that boracic acid, which had been hitherto supposed to be absolutely fixed, could be evaporated by the intense heat of the porcelain ovens; upon this it occurred to him that by dissolving alumina in boracic acid, which could be done by heat, and then evaporating the liquid, it would be possible to obtain crystals resembling the oriental stones; and it was found, in fact, that by exposing a platinum capsule containing such a mixture to the heat of the porcelain oven for a considerable time, the boracic acid was evaporated, and a number of little shining crystals of alumina having the properties and appearance of small precious stones were left adhering to the capsule, but

adhering so tightly that it was found impossible to detach them entire.

One other experiment is worthy of notice before proceeding to the only one which had any practical result; it is that of M. de Senarmont, who obtained similar microscopic crystals by exposing hydrate of alumina, or alumina combined with water, to a great heat, which caused the water to evaporate, and left the crystals at the bottom of the glass tubes in which the experiment was conducted.

The perseverance of M. Gaudin, who appears never to have abandoned the idea of manufacturing precious stones, enabled him, in 1857, to present to the Academy of Sciences several white sapphires produced by a very simple process, and of sufficient size to be used as jewels in watches.

The following is the mode of procedure by which M. Gaudin succeeded in producing these crystals :—

In a crucible lined with animal charcoal are placed equal parts of alum and sulphate of potash, previously calcined to expel the water. With this mixture the crucible is half filled; it is then filled up to the top with animal charcoal, the lid is put on and cemented in its place with clay, and it is then exposed in a furnace, and kept at a white heat for a quarter of an hour. The heat and the reducing power of the charcoal cause the formation of sulphuret of potassium, which fuses and dissolves the alumina; the continued action of the heat partly evaporates this sulphuret of potassium, and the alumina separates in the form of little crystals. On opening the crucible, a black mass, sparkling with brilliant points, is found in it, which consists of sulphuret of potassium mixed with crystals of alumina. This mass is afterwards placed in diluted nitro-hydrochloric acid, which dissolves the sulphuret, and lets fall the crystals of alumina to the bottom of the vessel, where they appear as a coarse powder, and, seen through a microscope, have an exact resemblance in form to the natural precious stones. By using a larger crucible, and exposing it to the action of the fire for a longer period, M. Gaudin produced crystals of much greater dimensions, which, upon examination, proved to be true white sapphires, and were even superior in hardness to the rubies ordinarily used for the jewelling of watches. He endeavoured to produce coloured crystals by the addition of metallic oxides, but found that these were invariably reduced into metals by the action of the charcoal. The successful result of this experiment encourages us to hope that at a future period M. Gaudin, or some one else possessed of his indomitable perseverance, may discover some substance capable of dissolving carbon in a similar manner to that in which sulphuret of potassium has been found to dissolve alumina, by which the

problem of the artificial production of that beautiful and valuable stone, the diamond, will at length be solved.

Although not belonging strictly to the subject of the artificial production of precious stones, it will not, perhaps, be thought inappropriate to notice some experiments undertaken by Messrs. Deville and Wohler, which resulted in the discovery of a crystal strongly resembling the diamond in its hardness and properties, although of a different composition. This crystal is that of a substance called boron, which attracted the attention of Messrs. Deville and Wohler on account of its resemblance to carbon. It occurred to these gentlemen that a substance having such a great similarity to the element of which the diamond is composed would, in all probability, if crystallized, have some characteristics in common with that gem. They, therefore, set to work to find some process which would enable them to reduce it to the crystalline form.

Boron is only found in nature in combination with oxygen, as boracic acid, and in union with soda as borax; and it had, up to this time, been obtained from these combinations only in the form of a brownish-green powder, insoluble in water, and possessing many of the properties of carbon. It was reserved for the two chemists whose names are given above to produce it in a form hitherto unknown, by the following process:—

In a crucible lined with animal charcoal are placed eighty grains of aluminium and one hundred grains of boracic acid; this crucible is then exposed for five hours to an intense heat, which causes a portion of the boracic acid to part with its oxygen to the aluminium. After it has been taken from the furnace and allowed to cool, it is found to contain a sort of glass composed of the remainder of the boracic acid and of the alumina formed during the process of heating, and underneath this a grey metallic mass sparkling with crystals. This mass consists merely of boron imbedded in aluminium. To separate the boron, the mass is plunged into boiling caustic soda, which dissolves the aluminium, and is afterwards treated with hydrochloric acid, to remove all traces of iron, and with a mixture of nitric and hydrofluoric acids, to get rid of any silicon that may have been left by the soda. After all these processes have been gone through, the boron remains alone.

An examination of the boron obtained in this way shows what a great analogy exists between it and carbon, which, as every one knows, is found in three forms: uncrystallized in charcoal; semi-crystallized in plumbago; and crystallized in the diamond. Similarly the boron resulting from the above experiment is found to exist in three forms, viz.: in black flakes almost as hard as the diamond; in brilliant prismatic crystals less hard than the former variety; and in small, beau-

tifully-formed reddish crystals, having a great resemblance to the diamond. These crystals are as hard as the diamond itself, and may, in course of time, should their manufacture be brought to perfection, supersede that stone in many of its uses, such as cutting and polishing precious stones, forming jewels in watches, &c.; and thus, although from their being unknown in nature they cannot be considered precious stones, the discovery of these boron diamonds may prove of more practical value than all the attempts at the artificial production of the real diamond.

ON THE WHITE CLOVER.

BY MRS. LANKESTER.

THERE is, perhaps, no natural order of plants more easily distinguished than the Leguminosæ, or Pea tribe; yet for the most part people are content to recognize the external characteristics of the different plants of this order, leaving unstudied the many interesting points of structure which are apparent in the humblest and most common representatives of the family. With the view of thoroughly examining the attributes and peculiarities of the order, so as to render them familiar to all who desire to make their acquaintance, we have chosen the most easily attainable and most abundantly common member of this interesting family as the subject of our present paper. Perhaps it cannot be positively asserted that the Dutch or White Clover is truly a native of the British Isles; but it is now so long since its introduction, that we may claim for it the privilege of naturalization, and safely reckon it amongst our British plants.

The main and universal characteristic of the order Leguminosæ is, that it consists of plants bearing pods, or legumes; and, as the order derives its name from this circumstance, it is important fully to understand the term; it is, in fact, a superior (that is, above the calyx of the flower) one-celled, one or many seeded fruit, opening on the upper side of the pod so as to form two valves. The seeds are fastened to one side only of the case alternately to each valve, by short pedicels or stalks. A pea-pod forms a very perfect example of what a legume really is, but the forms and varieties this organ may assume are numerous. It may be twisted like a screw, as in the Lucerne; coiled round like a caterpillar, as in *Scorpiurus sulcata;* curled like a snail, as in *Medicago;* or curved like a worm, as in some species of Acacia; still it is a legume, and preserves its resemblance to the pea-pod, in opening in the same manner if a little pressure be applied to the top, as in the process of shelling peas. The varying size of the legume is also another point worthy of notice. It is very minute in many of the British species of the order, as in the small clover, whilst in some tropical forms of Cassia it attains a length of two or three feet. It is worthy of remark, however, that it is always constructed on the same plan.

Then comes the singular arrangement of the petals, which, in the first subdivision of the order, *Papilionaceæ,* has been fan-

cifully likened to a butterfly. To this subdivision belongs our selected example, the Clover. The calyx of all leguminous plants is apparently composed of one entire piece ending in five distinct points, or perhaps they may be described as five sepals united together in a tube. The corolla consists of five parts or petals, one of which is larger than the rest, and stands up at the back of the others, forming a sort of covering or mantle to them before the flower expands: this is called the standard, banner, or vexillum. In front of the standard, and practically adherent to it, are two side-pieces, or *wings*, which are carefully folded over a projecting or boat-shaped part of the corolla, which comes prominently forward, and is called the *keel* or *carina*. This is formed of two petals, slightly adherent by their lower edges to each other. In this keel or cradle, as it were, lies hidden the provision which nature makes for the growth of future generations of like plants. We have thus traced the five portions of the corolla, which correspond in number to those of the calyx, but are so disguised by their curious arrangement that they might not be easily recognized.

We might almost say that the fanciful names applied to the different parts lead to confusion, for the original figure of a butterfly is curiously lost in the addition of a standard or banner at its back, and the keel or prow of a boat in front. Consistency, or regard to the real purpose of an organ, is very frequently overlooked by poetical naturalists.

The young fruit, protected by the keel or valve, is at first surrounded by a sort of membrane formed by the filaments of the stamens, which are united below, but distinct above, and surround the germ or bud of the legume. These ten filaments only appear to be united together at their base, for on close examination we find that nine only of them adhere together, and that the tenth gradually separates itself from the rest, leaving an opening by which the fruit or legume, when it is formed, can extend itself and become developed. On the top of each of these threads there is the yellow anther containing the pollen dust, which falls on the centre body or stigma which terminates the style. This style is but a sort of thread-like continuation of the legume, to which it adheres even after its work has been done in conveying the pollen dust to the ovules, and so ensuring the production of the complete legume with its perfect seeds. The nine stamens, faithful to each other, wither and die together, leaving the discarded and solitary brother as their only representative. It was on account of this separation of the ten stamens into two groups of one and nine, that Linnæus made this group of plants to constitute his class *Diadelphia*, or two brotherhoods.

Leguminous plants are divided into those which have their

stamens united and their flowers papilionaceous, and those which have their stamens *separate*. To the first belong all the most commonly recognized plants of the order, and all our British and European species.

Not the least interesting feature of this leguminous family of plants is their seeds, the peculiar construction and germination of which are worth attentive study. If we call to mind the ordinary nature of seeds, we find that they have an external covering, or testa, surrounding a mass of white pulp, or meat, as it is sometimes called, which is the substance for which seeds are usually taken as food. This white substance, known by the name of *albumen*, but which is by no means the *albumen* of the chemist, encases the little embryo plant. Chemical changes go on in the substance of this albumen, and the starch of which it is principally composed is converted into matters suitable for absorption by the young plant, such as sugar and dextrine. The seed absorbs water from the soil in which it is placed, which, swelling its substance, causes it to burst its external case, and the little embryo plant protrudes, first downwards, with its tiny radicle or root, and then upwards, with its little plumule or stem. Usually the outside case in which it was nourished, but for which it has no longer any need, remains in the ground and dies away. The seeds of leguminous plants, for the most part, differ from other seeds in the fact that they are destitute of this albumen or internal substance which surrounds the young plant. In their case the embryo fills up the whole of the seed, and has nothing intervening between it and the testa. The seed consists entirely of two *cotyledons*, or seed-leaves, which cover the embryo, and which at the time of germination separate, allowing the plumule and radicle to escape from between them. They then assume the form of leaves, and rise out of the ground with the plant itself, presenting the curious appearance we must all have noticed in sprouting peas or beans, apparently carrying up the old seed on their stems. The seeds of such plants as we are speaking of are, in truth, merely well and skilfully packed leaves or cotyledons surrounding the precious germ of future life in the plant—the promise of perpetuity in itself.

A very interesting and instructive experiment may easily be performed by soaking the seeds of any leguminous plant in water, and watching from day to day the development and growth of the young plant, and the ascension or expansion of its protecting cotyledons. In the Papilionaceous division of the order the seeds are a most important article of commerce. Under the name of Pulse they are valuable as food to animals and to man. Peas, beans, lentils, and some others, are familiar instances. The curious little ground-nut (*Arachis hypogea*), which, when

sold in the shops roasted, is pleasant enough to eat, is another instance. We find, however, that this fruit does not possess the usual characteristic of the legume, for the pod in which the seeds are inclosed breaks or splits up irregularly. In some plants of this family the seeds are undoubtedly unwholesome, if not poisonous, and great care should be taken to avoid them: such, for instance, as the common Laburnum.

The second sub-order of the *Leguminosæ* is called the *Cæsalpinieæ*, or the Senna section. It includes only foreign plants. They have imbricated petals—that is, petals which wrap over each other in the bud, the upper one being in the inside, and each petal more closely resembles its fellow than those of the *Papilionaceæ*. In some cases the petals are absent. The plants of this division are chiefly those which are useful in dyeing or for medicine—senna, logwood, and the tamarind are amongst them; and, were we attempting to write a complete history of the remarkable products of the family *Leguminosæ*, we should find in this subdivision alone enough interesting matter to fill many pages. In Dr. Lindley's "Vegetable Kingdom" there is given a drawing of one of the Great Locust trees of the West, described by Martius as belonging to this subdivision of *Leguminosæ*, which is of such enormous dimensions that fifteen Indians, with outstretched arms, could only just embrace one of them. By counting the concentric rings of such parts of the stem as were accessible, Martius concluded that some of these trees now existing were of the age of Homer; indeed, several of them were computed to have seen even remoter times. It seems almost incredible that the modest little plant which we have taken as the representative of this great family should claim kindred with these mighty forest trees, and become the easiest exponent of their distinguishing characteristics.

The third subdivision of the order is called *Mimoseæ*, or the Gum-Arabic section. It consists chiefly of plants in which gummy and astringent matters prevail. The petals are regular and valvate in æstivation,—that is, they do not overlap in the bud. Various species of Acacia belong to this section. *Acacia formosa* supplies the valuable Cuba timber called Sabicu, of which was made the stairs of the Crystal Palace in Hyde Park in 1851. The astringent substance known as *Catechu* is furnished by several species of Acacia. The Rosewood of commerce, so well recorded in our domestic articles of furniture, is produced by a species of *Mimosa* from the forests of Brazil. A species of *Mimosa* is an object of interest in our conservatories and greenhouses on account of its sensitive properties. There are but few of us who have not been amused with watching the closing, shrinking leaves of *Mimosa sensitiva*, when touched or handled.

This very slight sketch of the nature and products of this great natural family will be sufficient to show how very important a section of the vegetable kingdom it is. In our own country, the representatives of the order are chiefly confined to small herbaceous plants; they all retain the characteristic papilionaceous flowers and diadelphous stamens, and are perhaps not less valuable for their properties than their more showy and striking relatives—the inhabitants of warmer climes. To whatever magnificence these may attain, or under whatever form they are recognized, we find that they still possess one or other of the family features: in many cases the papilionaceous flowers have disappeared, but the leguminous fruit remains; or it may be that the flower still retains its butterfly shape, and the form of the fruit is changed.

But to return to our text—the Papilionaceous division of the order. The Liquorice of commerce, *Glycyrrhiza glabra;* the Indigo, produced from various species of *Indigofera;* the Locust-tree, which yields such beautiful timber; the graceful Laburnum, with its lovely golden drooping flowers; the charming Wisteria; and the unpleasant substance known as Cowitch, which is the sharp hair of the pods or legumes of a species of *Mucuna,* and many other interesting plants, all claim kindred under the name *Papilionaceæ,* being separated only by generic distinctions. Our modest little friend, the White or Dutch Clover, belongs to this subdivision, and is referred to the genus *Trifolium.*

This genus is one of the most extensive in the vegetable kingdom. It is known by the flowers being collected together in heads. The calyx is tubular, five-parted; the corolla is papilionaceous, consisting of the five petals which remain after decay; the stamens are diadelphous, more or less closely attached to the petals; the legume ovate, with one, two, or sometimes three or four seeds. All the species are herbaceous, and are included under the general name Clover, which includes some of our most important agricultural products. They are annual, biennial, or perennial plants, and are distinguished by the triple or three-parted leaf; from which they derive their name Trefle, or Trefoil. There are above twenty species natives of Great Britain, more or less valuable as fodder, and some of them are considered as indispensable to the farmer in the improved system of farming by a rotation of crops. The species chiefly cultivated are the Purple Clover (*T. pratense*); Cowgrass, or Perennial Clover (*T. pratense perenne*); Alsike Clover (*T. hybridum*); Zigzag Clover (*T. medium*); Scarlet Clover (*T. incarnatum*); Hop Trefoil (*T. procumbens*); and the White or Dutch clover (*T. repens*).

This latter species is the one about which we are at present

chiefly interested. It grows rapidly and forms excellent pasture, but its bulk is not sufficient to make it profitable to mow it for hay. Sheep thrive well upon it, and there are but few meadows or moors where it is not to be found. So common is this little plant in almost every plot of ground in our country, that it is as familiar to us as any other wild plant. The more pretentious, larger, and showy species of clover, do not appear except under cultivation, and seem to owe their existence more to the agency and care of man than does our modest little friend, the White Clover. Withering says, "On the soil of our moors in the north of England being turned up for the first time and lime applied, white clover appears in abundance; a circumstance in no way satisfactorily accounted for, but which is known to take place in wastes both in Britain and North America." In such situations the seed may have lain dormant for a length of time, until stimulated into vegetation by the admission of moisture and heat.

The common plants of a country are almost universally associated with its legends and poetry. The Irish names for the *Trifolium repens* are Shamrock—Shamrog, or Seamur-oge; and some botanists claim for it priority as the national emblem of Ireland. Many and warm have been the disputes to determine which of the three-leaved plants is the veritable shamrock. Some contend for the *Oxalis Acetosella*—wood-sorrel; while others maintain that the white clover is the favoured plant of St. Patrick, who, when preaching the Gospel in earliest times to the benighted inhabitants of the Emerald Isle, chose to illustrate the great doctrine of the Trinity by the simple instance of a triune nature in this well-known and beautiful leaf. Whether he plucked for the purpose the bright-green leaf of the wood-sorrel, or the familiar herbage of the white clover, cannot now be well ascertained. We are inclined to think that the national symbol is equally preserved in either plant; and in Ireland at this day, the trifolium is necessarily more frequently adopted than the oxalis by those who keep up national customs.

It would seem to be the tendency of nations to dedicate to their patron saint some plant with which they are familiar at that season of the year when the feast in his honour is celebrated. Thus, the Welsh have given the leek to St. David, as almost the only green thing to be found in Wales on St. David's Day. The Scotch have adopted the thistle for St. Andrew, whose celebration falls in the autumn, when thistles are abundant. Our own champion, St. George, seems by his warlike temperament to have discouraged anything like the sentimental dedication of a flower to his memory. This idea rather discountenances the notion that *Trifolium repens* is the veritable

trefoil of Ireland, for it does not arrive at perfection until considerably after the 17th of March, or St. Patrick's Day. The term Shamrock seems to be a general application for all trefoils or three-leaved plants, both in ancient and modern poetry and prose. Piers, in speaking of the early spring-time in Ireland, says, "For then the milk becomes plenty, and butter and new cheese, and curds and shamrocks, are the food of the meaner sort all this season:" and Wither, in his "Abuses Stript and Whipt," written in 1613, says:—

> "And for my cloathing in a mantle goe
> And feed on shamroots as the Irish doe."

This notion of using the shamrock as food renders it more probable that the oxalis was meant than the clover, although either might have been devoured by the starving peasantry so graphically described by Spenser, in his "View of the State of Ireland." He says:—

> "Out of every corner of the woods and glynnes they come creeping forth upon their hands, for their legs could not bear them; they looked like anatomies of death, they spoke like ghosts crying out of their graves, they did eat the dead carrions, and if they found a plot of watercresses or *shamrocks*, there they flocked as to a feast."

An Irish friend of ours who sticks to the oxalis, which is a lover of woods and shady places, as the veritable shamrock, quotes the "Irish Hudibras" against our Trifolium:—

> "Within a wood near to this place
> There grows a bunch of three-leaved grass
> Called by the boglanders, 'sham rogues,'
> A present for the queen of shoges (spirits)."

However, Irishmen now-a-days are for the most part content to mount a sprig of clover on St. Patrick's Day, for the cultivation which has brought in the more useful plant has in a great measure driven out the more poetical oxalis.

In all ages there has been a sort of mystic reverence surrounding the notion of a Trinity, and this idea seems embodied by the imaginative and poetical Irish in the triple leaflet. Whenever this sacred leaf is found to depart from its usual form, and to produce four leaflets, its mystic power is said to be greatly enhanced, and the fortunate finder of the leaf is sure of good fortune for life. Its power in dispelling illusions will account for the story of the maiden who, on returning from milking, saw the fairies dancing gaily on every rising ground, though her companions could discern nothing, and would not believe her until it was discovered that accidentally a four-leaved trefoil had got into her shoe, and had overcome the "illusion or defect of sight," which prevents ordinary mortals from seeing

the fairy beings by which they are always surrounded. In course of time the finding of the "four-leaved shamrock" was supposed to be the omen of a speedy and happy marriage (the imaginary ultimatum of bliss) to the youth or maiden who discovered it, and it became the custom to search for it after every harvest-home feast. The old song, "I'll seek a four-leaved shamrock in all the fairy dells," tells of the enchantments to be woven with the mystic leaves. The national dances of the Scotch, Welsh, and Irish, assuming with greater or less variation the nature of a reel and the described figure of eight, have their origin in the quatre-foil or four-leaved figure, which is woven by the dancers, and is associated with ancient superstitions.

With the garniture of all these poetical and historical associations, our little specimen tuft of White Clover seems to assume vastly more interesting and pleasing relations than when regarded merely as a sort of pasture grass, or as food for cattle. Important as are its useful qualities, we are insensibly more attracted to examine its minute and beautiful structure, when we call to mind all the bits of fancy surrounding its modest leaves; and we stoop to gather a handful of its simple white blossoms, or triple leaves, with something of a poetical sentiment within us. When we have examined its parts carefully and minutely with a botanical object in view, it is possible we may feel that the real poetry of nature lies deeper than is revealed to the more careless observer, and, like most things that are worth having in life, must be sought for to be enjoyed. In the dark gloomy month of December, in the midst of London fogs and frosty nights, one might well despair of finding anything like a botanical specimen; yet under such hopeless circumstances have we discovered the little *Trifolium repens* patiently nestling in a suburban garden until the warm days of spring should beam forth to invigorate and strengthen its tiny leaves, and develop the little white blossoms which are there in unseen preparation. In April or May we find it in full perfection; and throughout the summer it shares with the daisy the spontaneous duty of carpeting our meadows, downs, and uncultivated lands, at the same time well rewarding the care and skill of the farmer who encourages it to establish itself in his pastures.

The creeping underground stems of the Dutch clover favour its spreading and rapidly-increasing tendency; and, in digging up a specimen, we find that we have to remove several little rootlets, which are connected together by this creeping stem. It would appear, that when the first little plant is formed from the tiny seed it throws out this stem, which, after pressing on for an inch or so, sends up a little bud which soon expands into a perfect plant, having delicate rootlets like its predecessor;

this gives out another portion of stem, which ends in another little plant, and so on, till in a very short time a large space of ground is covered with its pretty green leaves and white flowers. When not in flower the *Trifolium repens* may be somewhat difficult to recognize, as its triple leaves are but slightly different from other species of the same genus. We will suppose that, tired with a country walk in the middle of a warm day in April, we have thrown ourselves down on a green bank, or a tempting sunny spot on some richly "carpeted and sheep" trodden down. Our eyes naturally seek the couch on which we rest, and almost certainly, in whatever locality we may be, we shall see all around us the tiny three-parted leaves of Trifolium conspicuous amongst the other herbage, which makes the natural beauty of our lanes so great. In two square inches of turf on which we were dreamily resting one warm day, last July, we counted eight different species of plants—all so closely matted and packed together that, without the temptation of having nothing else to do, we should scarcely have examined closely enough to distinguish them. With a botanical pocket-glass in our hand we carefully looked at each little verdant tuft in the measured space, and there sure enough was the never-failing little Dutch clover (*Trifolium repens*), the Bird's-foot Trefoil (*Lotus corniculatus*), Gold-dust (*Galium verum*), the Common Cranesbill (*Erodium cicutarium*), with several species of grass. By our side sat a friend whose thoughts seemed never to have descended so low before, and great was his surprise when this variety of vegetation in so small a space was pointed out to him. Having a botanical tendency ourselves, we were provided with a little tin vasculum, or sandwich-case, into which we placed the two square inches of turf for closer examination at home. A bright luxuriant plant of white clover suggested its suitability for a lesson in botany to our unscientific friend; accordingly it was ruthlessly pulled up by the roots, bringing with it other plants of its own kind attached to the creeping stems—some just forming, others in perfection. Those who are in earnest to know something of botany—something of the great vegetable world by which we are surrounded—cannot do better than follow our example. In choosing one simple little plant as a representative of any of the great families of plants, they will soon find that they are led on imperceptibly to a full acquaintance with the greater and more complicated discoveries of science.

We will imagine, therefore, that we have our tufts of *Trifolium repens* before us (plate xix.). If we wish preserve it fresh for some days, and to examine at our leisure all its parts, put it into a saucer with a little moisture and cover it with a hand-glass. Here, then, is the pretty white or whitish head of

flowers. Each little tiny flower growing in the round white head is a perfect type of the order to which it belongs, and possesses all the characteristics which we have described in the Leguminosæ. There is the tiny calyx, with ten little markings or ribs on its surface, and cut into five small teeth at the top, two of which are longer than the others. This contains the corolla, with its curiously-shaped parts; the two side petals or wings, the protruded keel in front, and the standard or erect petal at the back (fig. 3). This is sometimes marked and striped with a pinkish colour. The keel incloses the ten stamens (fig. 4), nine together and one alone; and the style, which becomes in time the legume, or the pod (fig. 5), containing the little seeds (fig. 6). Very frequently we may notice as the season advances that the white heads of the clover are fringed round with dead or withered flowers, which lose their upright position and hang down level with the stalk. These are the flowers which have performed their function: they have matured the provision for future life within themselves, and contain the tiny pod, with its two or three seeds which will perpetuate their species. Contrary to the general law in plants, the petals do not fall off when they wither and the fruit is formed, but remain persistently on the flower-stalk and calyx until the whole plant perishes. The outer row of flowers, coming first to perfection, fall downwards and form this brown fringe-like appearance round the head.

Having carefully examined every part of the flowers, let us take a leaf with its thin delicate stalk, and observe the beautiful markings on its surface, and the crescent-shaped figure which is impressed towards its base—sometimes hardly perceptible, at others of a darkish purplish colour, and very distinct. This coloured marking of the leaf sometimes extends over its whole surface, and clover leaves are often found in which the green colouring matter, or chlorophyle, has entirely assumed a purple hue. This change suggests to us that it is by no means essential to the nature of a leaf that it should be green. In the varied and beautiful tints of autumn, who has not been struck with the almost gorgeous colours of leaves? Bright red, brilliant orange, and deep purple, vie with each other to compensate to the eye for the absence of summer flowers. And in these very flowers, whose coloured petals at first sight seem altogether different from the surrounding leaves, we may shortly be able to trace evidences of identity with the green forest around them.

Let us now place one of the three little leaflets under the microscope. The markings are very distinct, and the edges of the leaf which appear so even and smooth to the naked eye are seen to be surrounded with points, towards each of which a

vein or rib is directed, and in an angle from which another vein proceeds. The little stomates, or breathing-pores as they have been called, are seen very evidently in this leaf; but as these interesting organs have been fully described as they occur in the Daisy,* we will not go into their history here. The microscope shows us that the ribs of the leaves are composed of woody fibre and spiral tissue, and in making a section of the stalk of the leaf the bundles of this beautiful spiral tissue are very abundant. No object can be more attractive than this very delicate and beautiful material; it seems to abound chiefly in the stems of plants, as if nature had provided this elastic contrivance as a precaution against the rough blasts and storms, which would prove destructive to a less pliant and yielding tissue, and rudely snap asunder the support of the unprotected leaves and flowers. In our specimen we shall find flowers containing the little pods and seeds, which latter are interesting on examining them in their various stages of development. When first formed they consist, as in all other leguminous plants, principally of the young embroyo. As this little embryo grows and develops it lives upon the food provided for it in its cotyledous or seed-leaves, and if we place the tiny seed in circumstances favourable for germination, we shall soon discover the living nature of its inhabitant. When kept dry the process of development does not go on in the seed; but if we place a few little seeds in moisture, or in some earth under a glass shade, we can then watch the growth of the young plant, and its liberation from its encasement. Just before the bursting of the seed, if we submit it to the microscope, we find that a great portion of the starch and sugar which distend the seed-leaves in an earlier stage have disappeared, and the various tissues can be observed which are to form the young plant. We can distinctly trace the imperfect spiral fibre and woody tissue; and now the form of the little embryo is evident. At each end is a little tail-like appendage, which, pressing against the external seed-case, causes it to burst open, and from it is sent downwards the radicle or future root, and upwards the little greenish-white plumule. In common with the rest of its order, this tiny sprout bears upwards with it the cotyledons and the forsaken seed-case, which remains attached to them during their short life. (fig. 2). All life seems to be but the preparation for a higher existence. The seed-leaves wither and give place to the stem-leaves, and these become perfected in the budding flower, which in all its beauty is but the temporary abode of those organs which have for their object the perpetuation of the species.

* See POPULAR SCIENCE REVIEW, No. 1.

In studying plant life, the fact is often forcibly presented to us that while all the designs of Nature seem to refer rather to the future than the present, yet each stage and phase of life is perfect in itself, and is none the less lovely or apparently content with its existence because it is transient and preparative for another set of organs tending to accomplish the higher ends of existence.

No class of plants affords such evident and interesting examples of the law of morphology in vegetables as do the *Leguminosæ*. In the white clover we frequently meet with cases in which parts of the flower exhibit a tendency to return to their leafy origin: the pod frequently changes into a small leaf, whilst the stamens, petals, and sepals all exhibit the same tendency, the pedicels of the flowers at the same time elongating. We have seen many specimens where the whole head of flowers on a stalk of clover has undergone this transformation, presenting the most singular appearance possible, with the green leaves looking as if quite out of their accustomed place, and, consequently, very odd and uncomfortable. In passing through a field of clover it is worth while to look for such monstrosities, and they are by no means uncommon.

We are indebted to the pencil of a lady (Mrs. Godwin-Austen) for a series of beautiful illustrations of the changes undergone by the flowers of the White Clover in their most sportive moods. (figs. 8, 9, 10, 11, 12). These were exhibited at the Meeting of the British Association, at Birmingham, in 1849, and were afterwards published in *Henfrey's Botanical Gazette* for March, 1850. Through her kindness we are enabled to give a sketch of some of the more interesting forms which these flowers assume.

It was a happy idea of the great German poet-botanist to reduce the previously received and complicated theory of plant structure to the simple formula of leaf formation. In this way everything presented itself to him under a different aspect:—what had been considered essential became accidental, and *vice versâ*. In all the higher plants, foliage, flowers, and fruit were regarded as essentially different parts. It was Göethe who first recognized in the flower and fruit the recurrence of the foliage, so that there is no essential difference between these three parts of a plant. In studying this subject somewhat carefully, it becomes evident that it is the leaf which, in its Protean capability of transformation, gradually assumes the form of fruit or flower. These are truly leaves,—whorls of leaves differing in character and position from other leaves, although not in their essential nature. This great doctrine of unity of plan in creation was first demonstrated and successfully taught in relation to the vegetable kingdom, and has since

been clearly worked out and adopted by the ablest comparative anatomists of this and other countries as applied to higher organisms, and even to man himself.

The susceptibility of the little *Trifolium* to the withdrawal of light, and its habit of closing its leaves somewhat on the approach of night, remind us of its family relationship to the group of Sensitive plants. While examining the tissue of the stems under the microscope, the abundance of spiral fibre suggested the thought that this very elastic and delicate material might possibly have something to do with the hitherto unexplained cause of the curious movements of the Sensitive Plants. Microscopic research, in skilful hands, will do much to clear up these unsolved questions; yet we cannot hope to see the time when, in the whole Ocean of Truth, there shall not be, even to the greatest and wisest of our race, hidden and unexplored depths, whose existence is only indicated on the surface by a gentle ripple, which excites no attention from the casual observer. Let us, each in his own way, be it ever so small, do what we can to trace out and mark

"Lessons of wisdom even in a flower."

DESCRIPTION OF PLATES XIX. AND XX.

Fig. 1. Plant of White Clover.
2. Seed of White Clover germinating.
3. Flower of White Clover.
4. Stamens of same.
5. Legume or Fruit.
6, 7. Seed.
8. Metamorphosis of the calyx teeth of the flower into leaves.
9. The Flowerets, consisting of a calyx larger than usual, with mere rudimentary traces of petals and stamens, and the plant passing over two stages of its flower structure proceeds directly to form a pod.
10. A specimen in which the stamens were distinct, but where one stamen had the form of a leaf, with two bract-like appendages, perhaps representing two other leaves at its base, together with a true stamen attached to the stalk at either side.
11. The Pistil metamorphosed into a perfect expanded leaf, leaflets occupying the place of ovules at its edge.
12. The Pistil represented by a leaflet which is metamorphosed into a pod, two abortive leaflets at the base of the imperfect pod on either side.

THE HUMAN HEART.

BY ISAAC ASHE, B.A., T.C.D., L.M.

THE ingenuity and yet simplicity of contrivance which the Creator so abundantly displays in every department of nature is, perhaps, nowhere so highly manifested as when He designs to provide for the existence and enjoyment of a sentient and conscious being; and doubtless it is to be anticipated, that as His creatures rise in the scale of conscious beings, so much the more abundant care would be bestowed in ensuring the welfare of their more highly endowed and more exquisitely sensitive frames. Accordingly, we have in Man the head of the terrestrial creation, the greatest amount and the most exquisite adaptation of contrivance, the highest evidence of design, and not only so, but of the beneficence and goodness of the Designer, and of His intention to render the human body in every respect a suitable and pleasant abode for the rational spirit destined for a time to inhabit it.

Hence, although there must always exist a considerable repugnance at first to the investigation of the structure of the body, yet, when this is overcome by the force of habit and professional duty, the beauties which are revealed in that structure are such as to fill with delight the thinking and intelligent mind which finds pleasure in witnessing the exquisite adaptation of means to the end which is to be accomplished.

The organ whose structure we have selected as the subject of the present sketch is the heart,—one which has always struck us as a masterpiece of ingenious design, perhaps, not to be exceeded by any part of the body, even the eye or ear, and one whose beauties are less generally known than those of either of these organs.

The heart, then, as all our readers know, is the principal means by which the vital fluid, the blood, is sent to every part of the body by a process of pumping quite analogous to what is seen in an ordinary forcing pump, though of much more delicate and perfect construction; indeed, it seems highly probable that the principle of the forcing pump was borrowed from this organ.

Now, what are the objects which have to be accomplished in this circulation of the blood, and how is the heart adapted to

their attainment; and what are the contrivances for the avoidance of those dangers which would, mechanically, be most likely to occur?

First of all, a supply of nourishment has to be furnished to every part of the body, no structure or organ being omitted; secondly, waste material has to be taken up and removed from the system after it has served its purposes there; and both these objects are accomplished by the circulating vital fluid, the first by a transudation of the watery part of the blood through the pores of the walls of those minute capillaries which ramify through every portion of the body, and which are too minute to permit the red corpuscles of the blood to escape, the function of these latter apparently being to vivify the watery portion or serum of the blood, which is the nutrient fluid: while the second of the objects above mentioned is attained by the blood circulating through various organs in the body, whose special function it is to remove used up material by peculiar vital processes, of which nothing farther is known than this, that they are effected by the same transudation of serum through the walls of the capillaries, or, in the case of the lungs, with which we are at present most concerned, by a similar passage of carbonic acid and water out through the walls of the air-cells of which the lungs are composed, while oxygen at the same time passes in by a similar process.

Through the other secreting and excreting organs, the blood, or a portion at least of it, passes in the course of the general circulation of the body, but through the lungs the whole of it passes by a separate circulation quite distinct from that of the body, and called the pulmonic circulation. Since the heart, then, has to effect two distinct circulations, it is necessary that it should be in effect double; and such is, in fact, the case, so that physiologically there are two quite distinct hearts in man and the higher animals, although anatomically the two are joined together. There are, therefore, four chambers, two for receiving the blood, the first on its return from the body, the second on its return from the lungs; these are called "auricles;" and two for expelling the blood through the circulation, the first through the pulmonic circulation, and the second through the systemic circulation, or that of the body; these chambers are called "ventricles." In the heart of fishes there are but two chambers, one auricle and one ventricle; in Batrachia, there are three chambers, two auricles and a ventricle; while in reptiles the ventricle has a partition which is imperfect in the lower classes, so that their heart has virtually only three cavities, but which becomes perfect in the Crocodiles, so that theirs, like that of birds and mammalia, is composed of four cavities.

This four-chambered heart is a muscle, and acts by means of muscular force. What the agent may be which irritates this muscle and so causes it to contract, has been a subject of much discussion; but it is now generally considered that this agent is oxygen, which is received into the blood in the lungs, and stimulates the muscular contractility of the heart through the nerves of the organ. This muscular action of the heart is almost entirely beyond the control of the will, as indeed are all the vital actions of the body; yet instances have been related of persons who were able to stop the heart's action at will, and in one case this experiment was carried too far, and the individual died by the mere act of his own will. On the other hand, the heart will continue its regular pulsations for a long time after its removal from the body, and of course the death of the animal; and the lower the creature in the scale of creation, the longer will this action continue; so that the heart of a sturgeon will continue to beat as long as twenty-four hours after its removal from the creature.

Through this four-chambered heart, then, the blood must pass in one direction only, and not indiscriminately backwards or forwards; and to effect this there is a whole series of beautiful contrivances. To begin with the first chamber, namely, the right auricle. As this chamber is dilating after each contraction it receives the blood which has been collected from all parts of the body into two enormous veins, and it also receives blood from some small veins which come from the substance of the heart itself,—for this organ has of course to supply blood to nourish its own muscular substance; but some force is wanting besides the mere dilatation of the auricle in order to ensure its being properly filled with blood, especially in the case of the vein, which, coming from the lower parts of the body, has to send its blood against the force of gravity, and accordingly these two large veins are provided with muscular coats for a short distance back from the auricle. There is a large opening between this auricle and the second chamber, namely, the right ventricle, an opening large enough to admit the tops of three fingers, and some of the blood flows through this opening at once, but the greater part of it fills the auricle which will contain about two ounces. It fills slowly, but the moment it is full it makes an extremely quick contraction, by which it forces nearly the whole of the blood through the opening into the right ventricle. Quick as this contraction is, occupying about the eighth part of a second, it can be observed to begin where the great veins enter the auricle, and to extend gradually over to the opening into the ventricle; and this is just what is necessary to ensure the driving of the blood gradually from behind forwards into the ventricle, and the blood cannot return up

the veins because the muscular contraction of their coats prevents it, in addition to which there is a most beautiful set of valves in the inside of the veins which only open towards the heart, so that the blood can pass that way, but not backwards. In the smaller veins of the body a pair of these valves can be seen at about every quarter inch, but they do not exist in the very small veins, nor in the great vein which comes into the right auricle from above; for, under ordinary circumstances, the blood is prevented from flowing backwards in this by the force of gravity, and under extraordinary circumstances it is sometimes necessary that it should flow back through it, as will be explained shortly. The walls of the auricle are very smooth, so as to allow the blood to pass freely along them, and they are not very strong, as they only have to force the blood into the next chamber, which is gradually opening to receive it. As soon as this chamber, the right ventricle, is full, it also contracts, but much more slowly than the auricle, since it has to overcome much greater resistance, for it has to force the blood along the pulmonary artery, and through all the capillary vessels of the air-cells of the lungs. And to effect this, its walls are very strong, and furnished with several muscular bands inside, which contract at the same time that the walls are contracting, and so both help the wall, as it were, and also by becoming thicker in consequence of their shortening, fill up the whole cavity of the ventricle, so that it completely empties itself of blood, which the auricle scarcely does.

There are, however, none of these muscular bands just at the mouth of the artery, lest they should cause obstruction to the free passage of the blood. But why does not the contraction of the ventricle force back the blood into the auricle which is just then dilating again? Because, inside the ventricle, and over the opening between the two chambers, there are three thin membranous valves which only open into the ventricle, but the moment the blood is driven against them by the ventricle beginning to contract, they are closed by its impetus, and, fitting accurately, completely prevent all regurgitation into the auricle.

The bases of these valves are connected with the opening all round, and their sides are partially connected with each other, so as to close the opening completely. But there would be considerable danger that the great force with which the ventricle contracts would drive the tips of these valves, which are in the centre when they close the opening, completely through into the auricle, and so allow regurgitation to take place notwithstanding, and the whole machinery to become hopelessly disorganised. To prevent this terrible accident, which would cause instant death, there are a large number of very fine but very strong branching tendons attached all over these valves on the

side next the ventricle, but principally along their margins, where there is the greatest danger of their being forced through, and the other ends of these tendons are united to the ends of muscular bands like those which help the contraction of the ventricle, the other ends of these bands being fastened to the wall of the ventricle,—so that they actually hold the valves like ropes, and so prevent them going through into the auricle: of course, these ropes, so to call them, must shorten as the ventricle contracts, and its wall comes near the opening, since otherwise they would not be tight, and would consequently be useless, and this is accomplished by the muscular bands contracting at the same instant with the ventricle itself, so that the tendinous threads are always kept tight, and the muscular bands relax themselves, and consequently lengthen, as the ventricle dilates, for, otherwise, they would tear the valves completely off their attachments. Thus we see the advantage of having these checks on the valves composed partly of tendon, which will not shorten nor lengthen, and partly of muscle, which will do so; for if they were all of tendon they would not contract nor remain tight, and the valves would be forced through, and if they were altogether of muscle the contraction would be too great, and would draw the valves inwards, so that they could not completely close, and the blood would regurgitate.

There is, however, another very beautiful arrangement here to prevent the blood being forced in too great quantity into the delicate vessels of the lungs during violent exertion, as this would rupture them,—a result which sometimes takes place in spite of the contrivance to avoid it, and hence we sometimes see runners and others spit blood after violent exertion.

This contrivance consists in having one of the muscular bands mentioned above very long, but placed nearly opposite the valves, so that though there is very little tendon attached to it, yet during a contraction of the ventricle the other end is brought so close to the valves that it does not draw them inwards nor prevent their complete closure; but if the ventricle should ever become too full, so as to endanger the lungs, then the other end of this muscle, being attached just opposite the valves, is drawn away a long distance from them, so that when this muscular band contracts it does draw the valves inwards, and allows the blood to regurgitate into the auricle, and from it into the great vein which comes from the upper part of the body, and so the pressure is taken off the lungs. Hence it is that the veins of the neck and face become distended during exertion; and the same thing is seen to take place during a prolonged note in singing, for then the blood does not pass so freely through the lungs, and this safety-valve action, as it is called, is brought into play. It was to this we referred when

we said above, that, under extraordinary circumstances, valves in the upper great vein would not only be useless, but even injurious, since it was necessary that regurgitation should occasionally take place.

The right ventricle then, as it contracts, forces the blood into the pulmonary artery, a large vessel which soon divides into two branches, one going to each lung. This vessel, like all other large arteries, has elastic walls, which yield under the impulse of the blood from the heart, and immediately afterwards contract again, as all elastic tubes would do after dilating; and thus they, as it were, store up the force of the heart's contraction, and transmit it along the whole length of the vessel for the purpose of forcing the blood on throughout. In addition to this, their yielding prevents their being torn by the force with which the blood is impelled into them by each contraction of the ventricle. Here, again, we have a beautiful arrangement to prevent the blood going back into the ventricle under the force with which the elastic artery contracts again. Three semicircular or semilunar folds of membrane, strengthened by fibrous structure, form valves, which are attached by their semicircular edges to the walls of the artery, while their straight edges look towards the centre. They are so loosely attached that they can be pouched out by the blood when driven back against them, and so driven out from the sides of the artery against which they otherwise lie, and be made to stop the opening. But it would be impossible to have muscular bands and tendinous cords inside the artery to hold these valves from going through into the ventricle, for such an arrangement would hinder the blood flowing freely along the artery, and accordingly we have other contrivances to prevent such an accident in this case. In the first place, from the shape of the valves, and their being attached by so much of their margin to the artery, there is less liability to the occurrence of such an accident; and, secondly, as the fleshy mass of the contracted ventricle lies close up under these valves, it gives them support for an instant, until the blood has passed on, and the artery just beyond the valves is once more empty. Since these valves, however, lie so close along the walls of the artery, and are attached by so large a margin to it, another danger is thus incurred,—namely, that the blood which has to shut these valves should altogether fail to get between them and the walls of the artery, and so should keep them open instead of shutting them. This danger is avoided by the elasticity of the artery, for, as the vessel dilates under the shock of the blood, it is evident that it will form pouches behind the valves, into which the blood must flow, and so act on them just as the water in a canal does on the gates of a lock, which it can never shut so long as they lie flat against the

banks, but shuts immediately if they are pushed out from the banks. Just in the middle of the unattached portion of the margin of each valve there is a little projecting fibrous particle which has been considered to be useful in effecting the same object, for, as it will touch the wall of the artery first when the valve opens back, it is evident that it will keep the rest of the valve out a little from the artery, and so always leave a passage behind it for the blood. These three little particles also, one on each valve, have been considered to be of use in another way when the valves are shut; namely, by filling up the very centre of the opening, which might otherwise not be completely closed, although the margins elsewhere overlap a good deal.

As the blood comes back from the lungs after being oxygenated, it is poured by four veins into the left auricle of the heart, which is the third chamber; and this, just like the right auricle, pumps it into the left ventricle through an opening a little smaller than that on the right side of the heart, and guarded similarly by a valve having only two leaves or flaps, instead of three, but provided with the same arrangement of cords and muscles, only that here there is no safety-valve arrangement as on the right side,—since, in the first place, the left ventricle may always, and can always, empty itself of the blood as fast as it is filled with it, for it drives the blood through the body, the structure of whose capillaries is much stronger than in the capillaries of the lungs, and consequently in no danger of giving way; and, secondly, if there were a safety-valve action, it would only overload the lungs, for there are no valves in the pulmonary veins to prevent it going back as there are in other veins; and thus the very mischief would be produced, to avoid which the safety-valve arrangement is provided on the right side of the heart.

The left ventricle, or fourth chamber of the heart, is the strongest of all, since it has to drive the blood through the whole body, and it also drives a small quantity through the muscular substance of the heart itself. The great artery through which it sends the blood is called the aorta; it afterwards gives off branches, which again ramify until the subdivisions become innumerable and supply all parts of the body. Its opening is closed by three semilunar valves precisely similar to those closing the opening into the pulmonary artery; and as both these large arteries proceed upwards from the heart, the force of gravity aids the blood in shutting the valves. Sometimes, however, any of these valves may become diseased, and not act perfectly, and then death is sure to ensue shortly, and may be very sudden. We remember having a patient under our care, who suffered much, and died suddenly thus; and we found, afterwards, that every one of the three valves which

guarded the aortic opening had a large hole through the middle of it.

The muscular fibres, of which the substance of the heart is composed, and by the contractions of which its force is exerted, are very much interlaced, but the greater number of them are inserted, by both ends, into strong rings, of fibrous and cartilaginous structure, which constitute the margins of the openings from the auricles to the ventricles, and also from the ventricles to the two great arteries. The fibres which pass round the cavity of an auricle, and so form its body, are inserted by both ends into the cartilaginous ring which is between this auricle and its corresponding ventricle, and those which similarly form the corresponding ventricle are inserted into the same ring, just as in a balloon the cords which surround the balloon and those which come from the car are inserted into one and the same ring placed between the two. Some of the fibres of the ventricles are also inserted into the rings at the openings into the two great arteries, so are the arteries themselves, as well as all the valves above mentioned. In some of the larger animals, as the ox and the elephant, there is even bony structure connected with some of these rings. There are other muscular fibres which are circular, their ends being, if we may so speak, inserted into themselves, like the horizontal cords on a balloon; but to enter further on the arrangement of these fibres would be too technical for our present article.

Now, it is evident that, owing to all the motion involved in these contractions and dilatations of the heart,—motion to such an extent as even to make its pulsations visible externally between the ribs,—there would be a great amount of wear and tear, and friction against other organs, and so impediment to the heart's motion itself, and injury to it and other organs, if there were not some contrivance to obviate this result. Accordingly we have the heart completely enclosed within a beautiful bag, inside which it can work freely, without any inconvenience or danger to itself or the neighbouring organs. The structure of this bag, or closed sac, is admirably adapted for allowing freedom of motion. It consists of two membranes, which adhere closely to each other for a great part of their extent. The outer membrane is the strongest, and is continuous everywhere all round the heart, except where it is pierced by the lower great vein from the body; it forms a kind of sheath for all the other large vessels, till, at a short distance from the heart, it becomes lost on their coats. The inner membrane is very smooth and glistening, and after lining the greater part of the outer one, it leaves it near the great vessels, and attaches itself to the coats of these, and accompanies them for about two inches till they enter the heart, when it attaches itself closely to the outside of that organ,

being firmly adherent to it in every part, and completely continuous with itself; so that between the part which lines the outside of the heart and the part which lines the inside of the outer membrane, there is an empty cavity completely closed in, in which the heart moves about; and, to facilitate its movements still more, a small amount of oily fluid is secreted in the interior of this cavity by the shining walls of the inner, or serous, membrane. The arrangement of these membranes, which form what is called the pericardium, is a little difficult to explain without an illustration, and we well remember what difficulty we ourselves at first had in understanding it; but we may illustrate it by comparing the heart to a hand, with a glove fitting very closely, or rather adhering to it, thrust inside another glove fitting very loosely, the wrists of the two gloves being then sewn together, so as to form between the two a closed sac for the hand to move about in; and if we could then imagine a third glove made to adhere closely over the greater part of the second, but leaving it at the wrist, and, a little higher up, by some strange process losing itself by uniting with the skin of the arm, which in this case would represent the great vessels, the analogy would be complete.

There is yet another thin and smooth membrane which lines the inside of all the cavities of the heart; it is called the endocardium, and is continuous with itself and with the membrane lining the inside of the great vessels which enter the heart; and it is of this membrane, doubled on itself at the rings of fibrous and cartilaginous structure, and there enclosing some fibrous structure, that all the valves above alluded to are composed.

Strange to say, a wound of the muscular structure of the heart is not necessarily fatal, even though it enter the cavities, provided the valves and vessels are uninjured; the contraction of the muscular fibres is in so many different planes, that it may even close the wound and prevent bleeding. Thus there is an instance well known amongst members of the medical profession in which a soldier was shot through the heart, who still recovered, and lived for six years, and after his death the heart was opened, and the bullet found in it, in the right ventricle, lying against the thin muscular wall between the two ventricles. Nothing but the result of the *post-mortem* examination could have made such a case credible.

The development of the heart from its very earliest stage is interesting and remarkable. In tracing the early development of the higher animals, we find successive stages of progress, each stage corresponding almost exactly with the permanent or perfect state of a class of animals below that in question.

The heart, for instance, of all vertebrate animals is at first very like the circulatory organ, for a heart we can scarcely call

it, which is found in the perfect state of some of the lower invertebrata. It then attains the state of perfection in which it is found in fish, going no farther in that particular class; but in Batrachians, after passing through the first two stages, development is not arrested as in fish, but goes on to a higher state of perfection. In reptiles, the first three stages being passed through, advance is still made; while in the heart of birds and mammalia, including man himself, the highest state of perfection is at last reached only by passing through the others.

Accordingly, the earliest form in which the heart presents itself is as a solid compact mass of embryonic cells, not differing in themselves from the cells of which other organs of the body are constituted, since the cell is the primordial form in which essentially vitality resides, and of which all organized bodies are entirely composed. At first there is no cavity in this heart, but shortly afterwards the cells in the centre seem to exert repulsive force on each other and become separated, thus forming a cavity which, however, is still closed; a liquid next appears in the cavity, in which the central cells may be observed floating; but even before this, or before even the formation of a cavity, pulsation is observed to take place among the cells. To what such pulsation is owing is beyond our present, or perhaps our possible, knowledge; the cells are similar to those in other parts of the body, and yet from their very earliest laying down in this position, and mutual relation, the function begins which the organ is to discharge during the whole period of existence. These pulsations are at first very slow, about fifteen to eighteen a minute, and they simply propel the contents of the cavity to and fro. So far, then, the heart is analogous to the first shadowing forth of a circulatory system which we see in the lowest of the animal sub-kingdoms, the Protozoa, in whose transparent, gelatinous, celluliform bodies one or more clear pulsating spaces are observed in the interior of the cells, and which appear in some degree to effect a circulation in the soft substance of the body.

The fluid within the cavity soon afterwards assumes the characters of blood, having been at first a homogeneous fluid, like the circulating fluid in the class of insects. About the same time the cavity opens, forming communications with the great vessels in contact with it which have been developing themselves *pari passu*, and subsequently the cells of which the walls of the heart are composed, are transformed into fibrous and muscular tissues, and into epithelium, which is a name applied to the cells which constitute lining membrane, whether externally as the skin, or internally, as the mucous membrane.

About the same time the heart, which was a straight cavity hitherto, becomes curved like a horse-shoe, and shortly after-

wards divides into three cavities, which contract in succession; one of these is an auricle, another is a ventricle, and the third is a large bulb, which receives the blood as it leaves the heart. The heart has thus assumed the condition in which it exists permanently in fish, namely, a two-chambered cavity; for the bulb must be regarded as a vessel, and indeed soon splits up into a number of arches, which remain permanent in fish, and carry the blood first to the branchiæ or gills, and afterwards round the body; but in higher animals these arches become closed after a time, with the exception of three, one of which remains persistent, and forms the arch of the aorta; a second is the vessel which we mentioned above as connecting the right ventricle with the arch of the aorta before birth, and becoming closed in one part soon after birth; and the third is a similar vessel on the right side, which, however, becomes closed before birth. The part of the second one which remains open, gives off the artery to the lungs, which, of course, remains persistent; and some parts of the other closed arches still remain open, and become the arteries for the head and arms.

Next in order, in the development of the heart itself, comes the separation of the auricle into two chambers, thus giving us the heart of the Batrachians and lower reptiles (an opening, however, still remaining until birth, as is mentioned above); and then a division is formed in the ventricle also, which is completed before birth, and is found in the crocodiles, birds, and mammalia, including man himself. The bulb mentioned above becomes swallowed up in the ventricles, and the partition, after separating the ventricle into two, goes on, and separates the base of the bulb into two, thus separating the roots of the pulmonary artery and aorta.

We have thus given a brief outline of the structure, functions, and development of the heart, that beautiful machine by which circulation is kept up and nutriment supplied to all parts of the body. Who can witness such contrivance, such resource and ingenuity, without feeling himself compelled to acknowledge the existence of an Almighty and benevolent Designer? If it be true that "the undevout astronomer is mad," much more, we think, is the undevout anatomist, and they most unjustly libel the science, who say that the study of it has a tendency to foster atheistic sentiments.

We have seen this machine, the heart, at rest, as it is presented to the view of the anatomist, both at various stages of its development, and in its perfect state. It is possible even to witness it in motion discharging its functions, as it is presented to the view of the physiologist, yet even then we should have seen but the commencement of the wonders that exist there; for what those mysterious forces are which first develope its struc-

ture, and subsequently retain it in action, endowing it with that exquisite irritability or sensitiveness by which it becomes, on the application of suitable stimuli, a working, nay, a living and self-repairing machine, or what even is the essential force in those stimuli,—these are things which neither the knife of the anatomist, the microscope, nor chemical analysis, nor any other re-agent at our disposal can reveal.

Indeed, it is probable that they are beyond the scope of our present faculties to comprehend, yet they also are the works of the Creator, and, doubtless, intended to display His power and skill to intelligent beings; so that from our very ignorance and incapability for such knowledge here we are led to hope for a higher state of being, where, with more perfect faculties, we may be permitted to satisfy the longings of the mind for a knowledge of the hidden laws of the Creator, and so of the Creator himself, and to explore all those mysteries of nature which here are among the things unknown.

MISCELLANEA.

SCIENCE IN THE PROVINCES.

THE NORTHAMPTON SCIENTIFIC FESTIVAL.

RESIDENTS in the metropolis, unless they frequently visit the country, are little aware of the rapid strides which science is making in our provincial towns, of the number of votaries it enlists, and of the powerful influence exercised by these upon their less-informed neighbours, who have hitherto been completely absorbed in trading pursuits, but into whose minds the man of science is now beginning to infuse somewhat of his own intelligence and enthusiasm.

And not alone do the provincial associations elevate the taste and instruct the minds of those resident in their own immediate neighbourhood, but already they are to some extent contributing to the general fund of useful information by local exhibitions, and the results of local research.

A wise step has recently been taken by the department of science and art, in allowing the "Travelling Museum" of science to circulate throughout the country; and better still will it be if this museum be made to partake of the nature of a large snow-ball, and to gather substance as it rolls; for there is no doubt that most of the localities in which it is likely to be exhibited, would be both able and willing to send contributions to the central repertory of knowledge.*

But to return to our local institutions. About this time last year there was exhibited in St. George's Hall, Liverpool, about as excellent a collection of objects of natural history as we have ever seen in any provincial city in England, and everything possible was done to lend a charm to the exhibition.

So far as our memory serves, all the objects (with two or three trifling exceptions) were the property of private individuals, or public institutions, in the town and its vicinity. The Botanic Gardens sent its plants; the Museums of the town their stuffed animals and aquaria; local collectors exhibited their shells, minerals, and flowers; local fair ones provided refreshments and decorations; local *prowess* lent its martial strains to charm the ear; and local philosophers added their efforts to give a lasting aim to the exhibition, by delivering short addresses on scientific subjects.

Unfortunately "we" had at that time not yet seen daylight, and were

* It may not be generally known that the Committee of Council on Education have recently authorized the consignment of objects for exhibition in connection with the demonstrations of science classes, &c., in country towns. We are not acquainted with the conditions on which the "museum" is sent, but this information may be had on application to the Secretary, South Kensington.

consequently unable to record the proceedings; but Liverpool is not the only town that brings her offerings to the altar of science, and we are now able to notice a similar display, which was recently made in the smaller but not less important town of Northampton.

For this exhibition the inhabitants were indebted to the chemistry and natural history classes of the Mechanics' Institution, and it was a great success in everything, except its pecuniary results. It contained collections of objects of natural history; of archæological interest; and illustrative of scientific theories and various manufactures. These were numerous and well arranged, each object being labelled with a simple description of its nature and uses; and gentlemen well versed in the various branches of science were in attendance to give any explanations that might be required.

The industrial occupations and staple trades of the town and neighbourhood were well represented. Samples of wool and specimens of cloth in different stages of manufacture were exhibited by Messrs. P. P. Playne and Co.; of needles in their different stages, by Messrs. Millward and Sons, Redditch; of cocoa, by Messrs. Cadbury and Co., Birmingham; the different stages of the silk manufacture were shown by Mr. Scott; chemical preparations by Mr. Harris, of Northampton.

The local tradespeople sent philosophical instruments, pianos, tobacco, machinery, &c.; a printing machine was at work striking off copies of a commemorative poem, of which more hereafter; and as in the Liverpool exhibition, the gentlemen of the neighbourhood contributed numerous collections of objects in zoology, archæology, &c. In the course of the evening a series of dissolving views were exhibited, and, lastly, what to a stranger would have been by far the most interesting feature in the exhibition, a potter and a papermaker were at work at intervals in the same room.

As is usual in such undertakings, although a great many persons contribute materials for the show, there is always some one who "does" everything. The factotum of the exhibition was Mr. Harris, of Gold-street, to whom the greatest credit is due for the manner in which this exhibition was conducted.

Our informant says nothing concerning the musical strains which usually enliven these festivals, nor are we informed whether the fair ladies of Northampton followed the example of those at Liverpool, and spent weeks beforehand in preparing decorations to grace the exhibition; but one at least, whose *nom de plume* was "Laura," won laurels by the composition of some beautiful verses, which were printed and sold in the building, the proceeds going towards the expenses of the exhibition.

After referring to the events of the past year, and paying a graceful tribute to the memory of one whom the fair poetess styles "Sage, Artist, and Prince," she thus characterises the aim of those who have promoted the festival:—

Do ye ask for our aim?—Towards the Temple of truth
  With steady resolve and high purpose we tend—
Her pilgrims are we! Nor with vanishing Youth,
  Nor with fugitive years, must our pilgrimage end.

True—we ne'er may be joined to that Hierarch band
  Who with foreheads unveiled, view her lustre divine!
But at least in the Porch we may rev'rently stand,
  And kindle our lamps at the fire on the shrine.

True—the watcher must sleep, and the lamp must expire,
  And the fountains of life become frozen and chill,
And the eye lose the lightning that filled it with fire,
  And each pulse of Emotion and Passion be still.

True—of us and our acts may no record remain,
  Save a Memory treasured in bosoms that love us;
But, " Peace to his ashes—he lived not in vain,"
  Shall be the fond requiem that's uttered above us.

And now let us pass from the consideration of science in its most practical application, from cloth, silks, needles, and edibles, to its less utilitarian aspect. Let us quit the halls of the Northampton Mechanics' Institute, with their display of the works of nature and art, and travelling for an hour or so along the Midland Railway, let us enter the green fields round about Burton-on-Trent, and there study—

Fairy Rings.

In Burton there is an excellent institution called the "Midland Scientific Association," which reckons amongst its members a veteran botanist, the Rev. Gerard Smith.

This gentleman has devoted much time to the investigation of the so-called "Fairy Rings," objects well-known to the child of the humblest cottager, but the nature of which has puzzled the ablest men of science.

How is it that these grassy circles (which were in former times believed by the ignorant to have marked the footsteps of "fairies in their nightly revels") constantly increase in diameter without any visible cause?

Are they really produced by

—— "The nimble elves
That do by moonshine green-sour ringlets make,
Whereof the ewe bites not; whose pastime 'tis
To make these midnight mushrooms?"

Do these fairies, these creatures who still impart romance to the dreams of our childhood, really leave these verdant circles as fit emblems of their eternal youth?

The reverend botanist thinks not; so we will not only bow to his opinion, but we will also transcribe a few of his remarks on the subject.

"Fairy rings consist, generally speaking, of circles or parts of circles of grass, of a darker colour and more luxuriant growth than the surrounding herbage, the outer edge of the circle being well defined, while the colour and stature of the grass diminish and fade so gradually inwards that it is difficult to determine the exact limit of the ring towards the centre. Very commonly there is to be observed an outer and contiguous ring, much narrower than the inner, and of which the grass is either short and weak, or faded and brown, remarkably contrasting with the vivid green of the inner ring. On this brown ring, or just upon its margin, fungi

are found. The duration of fairy rings varies much; some disappear in a few weeks, others endure for years. A severe winter will obliterate the external traces of a ring, and prevent the usual crop of fungi appearing upon it at the proper season; but such rings often reappear, and are thus considered to have been suddenly formed. During the whole course of their appearance the rings increase in diameter, spreading outwards from the centre; the faded brown circle becoming rank with green and copious grass, and a fresh outer circle being formed of dead or feeble blades of grass. The rate of increase is various; some enlarging their diameter a few inches in the year, others as many feet. The circles frequently meet in the course of this gradual enlargement. In such cases the point of contact becomes obliterated; and when this contact occurs between the margin of several such rings the obliteration of the parts which meet leaves a variety of segments of circles upon the turf, which pursuing an independent course, and some increasing more rapidly than others, present eventually an unaccountable irregularity, and, as it were, patchwork of greener and paler, stronger and weaker portions of turf. When the turf is cut through such a ring at two contiguous points so that a breadth is taken up from the inner rank green, through the faded breadth, to the outer ordinary state, the soil of the faded ring is always found drier and of a paler colour than the adjoining parts, and abundantly impregnated with Mycelium. Indeed, a careful examination will show that the faded and impoverished condition of the turf of the outer ring, is due to the close investment of its roots by the mycelium of the fungi, which occupy the ring. The dimensions of the rings vary from 3 feet to 300 feet in diameter; they are at times very irregular in form, an accident arising either from the nature of the soil and the obstacles which they meet with in their circumferential expansion, or from more than one ring coalescing, and producing an outline of undulating curves. Such are the usual characters of these phenomena."

After giving a lengthened account of the various scientific theories, by which it has been sought to explain the appearance and growth of fairy rings, Mr. Smith accounts for them as follows:—

"The fungi," he says, "which are found just upon their margin, 'exhaust the fertility of the soil, in which their mycelium* prevails.' The ring then extends beyond the exhausted portion into the new soil. But both the *inner* as well as the *outer* portions of a 'fairy ring' have a decayed appearance; and on this head," the author continues, "careful examination of the impoverished grasses upon the burnt and faded ring will show that it is the mycelium investing the roots of the grasses themselves that occasions the decline of their growth, and not seldom their death." When, however, the "mycelium" has performed its functions, and produced young fungi, it decays; and instead of extracting the nutriment from the soil to the *injury* of the grass, it serves as a manure to its luxuriant growth. *Within* the ring the long grass has exhausted the soil, so it now spreads outwards, and widens in circumference; in short, to quote Mr. Smith's recapitulation, "the true explanation of the phenomena of fairy rings appears to be, first, the natural process of vegetation advancing from exhausted to virgin soil; secondly, the impoverishment of the turf by the investing mycelium of the fungi; and, thirdly, the revivifying and fertilizing effects of the decaying mycelium upon the same turf once withered and dried."

* The "Mycelium" is the interlacing filament from which the fungi spring up.

WARWICKSHIRE NATURALISTS' FIELD CLUB.

The winter meeting of the Warwickshire Naturalists' Field Club was held at the Museum, Warwick, on Thursday, the 13th instant. This was a joint meeting of the Malvern Club with the Warwickshire, and was tolerably well attended, though not so numerously as the occasion merited.

In the absence of the president, the Rev. P. B. Brodie, F.G.S., the Vice-president, took the chair. He opened the business of the day by welcoming the members of the Malvern Club, and then reviewed briefly the proceedings of the Warwickshire Field Club during the past year. He then called upon the Rev. St. John Parry, president of Leamington College, to describe a portion of an antler of the Red-deer, which had been found in certain beds of clay, supposed to be London clay, near Gosport. It exhibited marks of a knife or halbert; and a short discussion followed as to the true nature of the deposit in which it occurred; and the geologists present were unanimously of opinion that the clay would be found rather to belong to a drift than so old a formation as an eocene tertiary stratum. The Vice-president called upon the Rev. W. Symonds, president of the Malvern Field Club, to deliver his address on geological facts and theories. He commenced by giving an astronomical view of the history of the earth, combated the idea of an original universal molten condition of our planet, alluding to the early and first traces of life in the lowest or Cambrian rocks; and gave a brief review of Darwin's theory of the origin of species by natural selection, to which he expressed himself decidedly opposed, and so passed on to other interesting geological facts and theories.

The Rev. P. B. Brodie then gave a lecture "On the succession of life on the ancient earth." It occupied an hour and a half, and it is impossible, in a brief sketch, to enter into all the interesting subjects of which it treated. It was an extempore discourse largely illustrated by numerous drawings, diagrams, &c., which fully illustrated the topics discussed. The lecturer pointed out the influence of climate on land, and depth in the ocean, on the distribution of life. All the great types of life, he said, began simultaneously and independently. The life of the Palæozoic rocks was shown to be entirely marine, which was fullest in the Wenlock and Ludlow groups. Fishes and land plants first appear in the uppermost Ludlow zone. Ere the close of this epoch many forms of mollusks disappear, and are succeeded by other new and representative forms, to which ample allusion was made, in the succeeding formations up to the newest tertiary. The structure of the singular Placoid and Ganoid fish was pointed out, especially those of the old red sandstone, also of the Cycloid and Ctenoid orders, commencing with the chalk. The thirteen orders of reptiles, five of which are both recent and fossil, were largely dwelt upon and traced upwards from their first appearance in the Carboniferous series to their gradual extinction upwards. The structure and nature of the Salamander, like Labyrinthodon, was especially referred to, as the Warwick Museum contains the finest collection of the remains of this extinct reptile in the kingdom; and a fine suite of footsteps was exhibited to the meeting. The rev. lecturer thus traced the gradual development of life, from the lowest strata upwards, referring to the successive appearance of insects, myriapoda, reptiles, birds (some extinct), and, lastly, of mammals;

and concluded his address with a brief summary, reviewing this gradual development of life as indicative of a definite creative plan which binds the whole into one harmonious system.

Complimentary votes of thanks were then passed to the various lecturers by the audience, which consisted of the members of many neighbouring clubs, and included, we need hardly add, a great many of the fair sex.

The remainder of the day was spent in social intercourse between the members.

THE FIFTIETH ANNIVERSARY OF THE LIVERPOOL LITERARY AND PHILOSOPHICAL SOCIETY.

Liverpool possessed a Literary and Philosophical Society in 1790; not the one which has just celebrated its fiftieth natal day, but another, with which was connected the name of Edward Rushton, the founder of the "School for the Blind," an institution which still calls forth the admiration of all strangers who visit Liverpool.

The present Literary and Philosophical Society was founded on the 13th March, 1812, when fifty-six gentlemen enrolled themselves as members; but it was not until December, 1817, that the Society rendered its name permanent by the election as member, and on the same evening as its president, of William Roscoe.

Here is Mr. Roscoe's letter to the secretary, accepting office:—

"My Dear Sir,—May I beg that you will take an early opportunity this evening to express my respectful thanks to the Literary and Philosophical Society for the honour they have done me, and which you so obligingly announced to me, in admitting me a member and nominating me to the distinguished situation of their president, a situation the duties of which I shall be happy to discharge to the utmost of my power. If it will not be informal for me to make my appearance amongst you this evening, I will be in attendance in the ante-room, and will wait their pleasure.

"I am, my dear Sir, most faithfully yours,

"W. Roscoe."

Mr. Roscoe was introduced at the evening meeting, the members rose to receive him, and he signed the laws.

Amongst the gentlemen known in literary and scientific circles, who have since held office as presidents, we may mention Dr. Traill, J. B. Yates, F.S.A., Dr. Booth, F.R.S., Dr. Dickenson, F.R.S. The present occupier of the presidential chair, the Rev. H. H. Higgins, is most zealous in his encouragement of science, being an acting Vice-president of the Naturalists' Field Club; as is also Dr. C. Collingwood, the secretary of the Literary Society; a gentleman well known in the scientific world for his contributions to natural history.

It is no wonder that a society which, as our readers will perceive, has acquired more than a local reputation in the annals of science and literature, should seek to give some *éclat* to the silver year of its existence; and we find accordingly, that under its auspices the town-hall of Liverpool was thronged on the 13th of last month with a concourse of nearly 1,500 ladies and gentlemen.

The "west drawing-room" was devoted to the exhibition of philosophical

instruments, electrical and other experiments, and telegraphic printing; the "east drawing-room" to books, autographs, and manuscripts; the most conspicuous of the last-named being one of Roscoe's, of the Life of Leo X. The remaining saloons were devoted to the arts, to music, and painting; and the Council-chamber, &c., to refreshments.

The music consisted chiefly of part-songs, beautifully executed by the German "Lieder Tafel." The paintings in oil and water-colours, which were the property of the merchants and gentry in and around Liverpool, were collected and well hung under the superintendence of Arnold Baruchson, Esq., a patron of art in the town.

The Rev. President delivered a short address in one of the saloons during the evening, in which he sketched the history of the Society; and his place was then occupied by the only surviving founder present, the venerable and much-esteemed William Rathbone, the friend of Roscoe, as well as of all that is good and useful in Liverpool. He addressed those around him as his "children," and called up old associations in the minds of many who had lived with him when science was a heresy. After these addresses the concert followed, and brought the proceedings of the evening to a close.

Such meetings as this, and others, of which we hope to be able to record a goodly and increasing number in each new issue, are calculated to place science in its true light, not as a dry study, hemmed in by obstacles insurmountable by the populace, but as one of the chief occupations that render life useful and agreeable.

We congratulate the Liverpool Society on the success of its fiftieth anniversary, and hope that *it* may live to celebrate, and that these pages may record, the hundredth year of its existence.

TRANSLATIONS AND CONTINENTAL NOVELTIES.

The Kangaroo and her Young Offspring.—Die Natur, a weekly popular magazine of science, edited by Dr. O. Ule and Dr. K. Müller, and published in Halle, contains a series of articles by the first-named writer on "Marsupials Recent, and Fossil;" from one of which we extract the following wonderful anecdote connected with the natural history of the Kangaroo:—

"Weinland observed an interesting circumstance in connection with the development of these creatures in the new zoological garden, Frankfort. In the winter of 1860, a female kangaroo had given birth to a young one, which for the first time protruded its naked head, measuring two inches in length, from the maternal pouch on the 22nd of February. Towards the commencement of May, it ventured forth for a little while upon its own feet, and in the course of the summer it continued to disport upon the grassy lawn, and to grow in stateliness and beauty, under the guardianship of its parents.

"Although it had, in the month of September, attained to half the size of its parents, it was still frequently seen to seek refuge in its mother's pouch. With long leaps it would, at such times, come bounding towards her, under the apprehension of some imaginary danger, and without an instant arresting its progress on approaching her, it would plunge head foremost into the half-opened pouch of the mother, who was quietly seated upon her hind

legs; and twisting itself rapidly within the pouch, it would protrude its head with an irresistibly comic expression, indicative of a sense of security. Towards the end of September this young one, which was also a female, was seen in the pouch for the last time; but although it relinquished the *shelter* afforded by its parent, yet it continued to seek its nourishment from this source.

"On the 22nd of October the parent was still suckling her offspring, when to the utter astonishment of the observers, that peculiar tremulous movement was perceptible in the pouch of the *young one*, which left no doubt as to its condition.* Herself a mother; ay, even suckling her own offspring in her pouch, this creature still drew its nourishment from its parent."

War against the Locusts.—During the last two or three years Turkey, the Principalities, Bessarabia, and part of Russia have been visited by a plague of locusts; and we extract the following account of the means employed by the inhabitants of certain districts to stop the progress of these insects, from the same interesting journal which has afforded us the preceding anecdote:—

"It was supposed that the danger had passed away (June, 1859), when suddenly the news spread that incalculable swarms of locusts were on their way from Khersonese. A few days previously, indeed, these pests had crossed the Dniester at Bender. Forming a mass one and a quarter German miles (about four English miles), in breadth, and seven to eight inches thick, they occupied the whole of two days in swimming across the stream, and then spread themselves in all directions over the marshy lowlands lying on the left bank of the river. Here it was absolutely necessary to arrest their further progress, and a crusade arose, which, for violence and murderous results, is quite unprecedented in the annals of natural history.

"Germans, Bulgarians, Moldavians, Jews, and Russians, all hurried to the rescue, for each nation had its flocks and herds to defend from the terrible invaders, and in a brief space of time 14,000 well-armed men stood arrayed for the conflict.

"Meanwhile the locusts had occupied all the level country covering a superficial area of four square miles.† In order to prevent their inroads upon the surrounding fields, it was found necessary to excavate deep ditches in different parts along the boundary. These were guarded by persons whose business it was to kill the locusts as they fell into the ditches. The remaining people divided themselves into bands, or companies of hundreds and thousands, and with the aid of brooms and drags, constructed of dry branches, they commenced a vigorous onslaught upon the enemy as he advanced over the hedges and underwood, in ever increasing swarms. Wherever the ground was perfectly level, horses and oxen were employed in great numbers to trample the enemy under foot, and watchmen were appointed, who passed rapidly from post to post, and ordered bands of men to those portions of the boundary line which were in the greatest danger of being broken through by the advancing hordes of the enemy.

"The battle raged a whole week, during which three-fourths of the entire mass of locusts perished, and by this time the remaining insects had completed their metamorphosis, and were in full possession of their wings. On the 9th of July, the first swarms rose into the air, and flew off in various directions. Any further effort to destroy them was now deemed unnecessary, and the men were dismissed to their respective homes. But the slaughter had not been perpetrated in vain, for whilst in Khersonese the entire harvest had been destroyed by this insect, Bessarabia suffered but little."

* The tremulous movement referred to, indicates the birth and descent into the pouch of the partially-developed young of these animals.

† Four square German miles = about thirty-six square English miles.

REVIEWS.

METALLURGY.*

THE extraction of metals from their ores, and their manufacture for the various purposes for which they are peculiarly adapted, has necessarily been studied from the very earliest ages of antiquity, and has always awakened the energy and zeal of even the rudest and most unlettered tribes. The savage soon learned that, to practise the art of war successfully, he must obtain a substance harder and more durable than wood from the forest or stone from the quarry; a substance which could be forged, hammered into shape, tempered, and refined—processes which could not be employed in the workmanship of wood or stone. He learned, from experience, that his enemy, when fortified with metallic implements, although perhaps inferior in physical strength, had a power of endurance and defence superior to his own. Besides the warlike arts, the genial pursuit of agriculture and the comforts of domestic life were soon found to be dependant upon the application of substances, at once hard, durable, and comparatively pliable, and these acquisitions were only to be obtained in the metals. It would be curious and interesting, did our space admit, to speculate upon the rude metallurgy of those early days when Tubal Cain smote the anvil with his hammer and welded iron for the first time.

The ancients, as far as we can learn, were only cognizant of seven metals—gold, silver, copper, iron, lead, tin, and mercury—to each of which a symbol was assigned, in honour of some great object in Nature or a popular deity. Hence gold, the source of luxury and wealth, was called the sun; silver, the moon; copper (probably owing to its beautiful colour), Venus; iron (from its strength and employment in battle), Mars; lead, Saturn; tin, Jupiter; and Mercury, from the god of the winged heel. Zinc, although of no modern discovery, was only first mentioned by Agricola; the other metals being of more recent date.

Our forefathers, doubtless, were familiar with many of the earths, salts, &c., with which we are acquainted, but from want of analytical skill they were ignorant that these substances were metallic compounds. They knew not that the salt with which they preserved their food was merely the chloride of a metal—white and lustrous as silver,—that the chalky cliff and marble steep, the branching coral and glistening shell, were the carbonate of a metallic oxide,—that the ashes of their forests and the granite of their rocks contained a metal, which, in future ages, the genius of Davy would disclose.

* *Metallurgy: The Art of extracting Metals from their Ores, and adapting them to various purposes of Manufacture.* By JOHN PERCY, M.D., F.R.S.

In short, that the whole world itself, from the summit of its loftiest cordillera to the seething mass within its centre, was one vast sphere of metal, tarnished and dimmed by contact with surrounding elements.

And our forefathers, probably, distinguished the few metals with which they were acquainted more by their physical than their chemical characteristics. They knew that lead had not the lustre of silver, nor the latter the yellow gleam of gold, nor gold the reddish hue of copper; that tin was too soft a material from which to form the offensive spear or the peaceful pruning-hook, the weapon of the warrior or the implement of the husbandman; and that hard, enduring iron must serve the soldier in the conflict and the farmer at the plough; but they knew not the salts or the chemical compounds of the metals. Were those metals disguised, as they are in solution, they could not distinguish them from one another.

Modern chemistry teaches us to investigate these matters more closely, not to be content with the condition of a metal in its elementary form, but to understand the reaction it imparts when in combination with other bodies, and hence by certain and unerring tests to be able to affirm its presence, even when its metallic form is hidden from our eyes. Knowing the characteristic colours which the metal chromium can yield to certain transparent minerals, we can recognize its acid blazing in the ruby, or its oxide gleaming in the emerald's milder light; or cobalt, in the sapphire glass of some old cathedral; or manganese, in the amythestine spars of Derbyshire. Every metal can be known by certain phenomena which always accompany its combination, by the colour it gives to fluxes, or by the tints it imparts to flame.

During the last century, what numerous metals have been brought to light! The ancients recognized seven only—we are acquainted with about fifty; and the increased range of our experience has led us to alter, in certain respects, our preconceived notions of their characteristics. Metals were always described in earlier treatises as essentially *heavy* bodies, having a far higher specific gravity than water, but science has given us several which are much lighter than that liquid (such as potassium, sodium, and lithium); in many points, however, such as being good conductors of heat and electricity, they possess properties in common. Their chemical, as well as their physical characters are exceedingly diverse, some combining with oxygen with such avidity, even at ordinary temperatures, as to lose their metallic appearance after a few moments' exposure to the atmosphere, whilst others can be submitted to the strongest heat for many hours without suffering any change. It is interesting to trace these phenomena, as exemplified in the various metals, beginning with potassium and terminating, perhaps, with platinum or gold. Potassium, even in dry air, is soon converted into potash, and, as far as its metallic nature is concerned, would instantaneously perish in the dewdrop. Magnesium, although not so strongly affected, burns in the flame of an ordinary candle, emitting, during its combustion, the most vivid and beautiful light. Iron, the very symbol of enduring strength, speedily becomes oxidized, and, unless carefully shielded from external influences, rusts into the earth from whence it came. Copper, although in a less degree, soon becomes tarnished and grows dim. Even silver loses its lustre after the lapse of years, and cannot withstand the

action of the sea—for the treasure which Anson failed to capture, sunk by the Spaniards from their argosies, was found, after some time, to be coated with the chloride. While gold for ever would withstand the action of wind and wave, and only passes through the furnace to be purified and exalted *from* its fires. Undimmed by the breath of Time, unharmed by the wear of centuries, unaffected by the all-conquering oxygen, the metal first dug from the bed of the Euphrates, or quarried from the caverns of Ophir, is still fresh and brilliant as the glittering coinage of to-day!

The advancement of chemical science has, while leading us into a clearer knowledge of the properties of the metals, naturally taught us to investigate the various phenomena which accompany their extraction from the elements with which they were in intimate association, and the subject has proved so inviting that many philosophers have devoted years of laborious life to this special branch of technology. The work now before us offers a fair example of what long continued and patient experiment can effect; and the subject has evidently so grown under the author's hands, that, although we believe it was his original intention to comprise the whole matter in one volume, that which is already published only treats of two metals and their compounds, together with an elaborate treatise on Fireclays and Fuel. Another volume is promised shortly, which, it is stated, will conclude the work; but if we are not much mistaken, two or more will not contain all the important particulars the author has at his command, as we have yet to become acquainted with iron, lead, silver, gold, platinum, nickel, cobalt, arsenic, bismuth, antimony, tin, and mercury, all of which possess a very high, although not perhaps an equal interest.

Dr. Percy commences his introductory chapter by showing that a sound knowledge of chemical and physical laws is essential to the full understanding of any metallurgic process, and as an illustration, the ordinary system of copper smelting is adduced: "When an ore of copper, consisting essentially of copper, iron, sulphur, and silica, is subjected to a series of processes, such as heating with access of air under special conditions, melting, &c., copper is separated in the metallic state. The sum of these processes is termed the smelting of copper. In this operation of smelting, certain chemical changes take place. The sulphur combines with the oxygen of the air, and is evolved chiefly as sulphurous acid; the iron is similarly converted into oxide, which combines with the silica present, to form a fusible compound or slag. There are thus several facts which are proved on chemical evidence. These facts, when systematically arranged, may be said to constitute the scientific knowledge of copper smelting; and that knowledge necessarily implies a knowledge of the chemical relations of copper, iron, sulphur, oxygen, and silica to each other. There are many other facts connected with copper smelting, but those mentioned suffice for the present purpose of illustration. The man who conducts the process of copper smelting in ignorance of these facts, has simply an empirical, in contradistinction to a scientific, knowledge of the art."

We are then led on to the physical properties of the metals, the action of heat, the fixed and the volatile metals, specific gravity, crystallization, varieties of fracture, malleability, ductility, tenacity, toughness, softness, the relative power of conducting heat and electricity, &c.; and under this last head

the results of some very interesting experiments of Matthiesson's are given, showing that the conductibility of metals depends not only upon their chemical purity, but also upon their molecular structure. Hence, the conducting power of pure silver wire, *hard drawn*, is stated as equal to 100, but when *annealed** it is 110; and copper, which possesses the same power to a nearly equal degree, viz. 99·5, when hard drawn, only increases to 102 when annealed. The practical importance of these experiments must be apparent to every one, as upon the conductibility of metals, the whole system of the electric telegraph depends.

A great portion of the work is devoted to the study of the various kinds of fuel used at different periods for metallurgic purposes, and in the article upon coal there is an interesting notice of the occurrence of certain metals in the fuel we ordinarily consume. Daubrée has detected traces of antimony and arsenic in the coal of Newcastle-upon-Tyne, and in a variety of coal at Ville, in France, as much as 0·0415 per cent. of arsenic, besides traces of antimony and copper. "I have seen," continues Dr. Percy, "galena (sulphide of lead) in coal from Bedworth, and the anthracite of South Wales, which we have been accustomed constantly to employ in the metallurgic laboratory of the school of mines, contains decided traces of copper."

The subject of copper smelting is entered into minutely in all its important bearings, commercial, statistical, and scientific. Speaking about the enormous amount of poisonous gas annually exhaled from the copper-works of Swansea alone, Dr. Percy quotes Le Play as the author of the following interesting facts:—"Sulphurous acid forms twenty-one per cent. of the total weight of the sum of the fixed and volatile products of calcination, and twenty-five per cent. of the weight of the ore subjected to calcination; the weight of sulphur contained in this gas amounts to thirteen per cent. of that of the ore. During the entire process of smelting, the sulphurous acid and sulphur expelled amount, respectively, to fifty-six and twenty-three per cent. of the weight of the ore. The total weight of copper ore smelted in South Wales (some time before 1848) being about 200,000 tons, about 42,000 of sulphur were annually volatilized, producing 92,000 tons of sulphurous acid. In the works situated near Swansea, nearly two-thirds of the ore imported into South Wales are smelted, so that daily 65,900 cubic metres of sulphurous acid are projected from these works into the atmosphere. This acid, being very hurtful to vegetation, not a blade of grass will grow on the neighbouring hills, which are particularly exposed to its influence. The sulphuric acid contained in the copper smoke is probably more injurious than the sulphurous acid, as every drop of rain, in falling through the smoke, becomes a solution of oil of vitriol, which, alighting upon foliage, is rendered more corrosive by subsequent evaporation of a portion of the water. The value of the sulphur annually dissipated is estimated at £200,000."

The elimination of the various metals usually found associated with copper

* The process of annealing generally consists in allowing the metal to cool *gradually*, during which operation certain valuable properties are conferred upon it, depending, it is supposed, upon a different state of the physical arrangement of the atoms. When *hard drawn*, the *annealing* has been dispensed with.

is a matter of very great importance. It would astonish those who have no devoted much attention to metallurgical pursuits, to learn how sensibly the most minute traces of foreign metals interfere with the value of copper, rendering it, in many instances, hard and brittle when softness and malleability are required. So delicate are the manipulations requisite for the detection and estimation of all the impurities, often amounting collectively to only a few hundredths of a grain in one hundred of copper, that many experienced analysts have disagreed materially in the results of their investigations.

The importance of a knowledge of chemistry to those who have the management of smelting works is well illustrated in an anecdote related by Dr. Lyon Playfair to Dr. Percy :—"At large chemical works, where sulphate of copper was prepared by dissolving copper in sulphuric acid, an insoluble residue was produced in the process, which had been put aside from time to time, and had not fortunately been thrown away. A small sum was offered by certain persons for this residue, which had not previously been regarded as of much value. Suspicion was excited, especially by the quarter from which the offer proceeded, and it was declined. The residue was examined and found to contain £700 worth of gold."

Dr. Percy does not seem to imagine that many improvements either in the economy of the process, or in the purification of the copper, have taken place during the last few years. Numerous patents have been registered, from time to time, for effecting not only a great saving in fuel, but also a better reduction of the metal, and yet nearly all the copper works have gone back upon the old system, the saving of time and fuel not appearing to compensate for the inferiority of the copper produced too rapidly. A smelter of great experience has assured Dr. Percy that better copper was formerly made by what was termed the *dry* roasting than that made at present by *wet* roasting. In the former case the regulus underwent a long course of treatment at a moderate heat, in which the volatile metals were eliminated ; in the latter the regulus is run down at once, and kept liquid until all the sulphur is expelled.

It is to be regretted that our space will not admit of even a hasty glance at the metallurgy of zinc, which concludes the volume before us, a volume abounding in facts of the greatest importance, not only to the practical smelter but to the political economist and the philosopher. The statistical accounts of the quantity of coal annually consumed in metallurgic operations, the imports and exports of metals in their rough as well as their manufactured condition, the smelting of other countries compared with our own, cannot fail to interest all those who have the advancement and prosperity of these kingdoms at heart. The plates with which the work abounds are no ordinary illustrations, apt to mislead the novice in metallurgy, but true and correct sketches, according to exact scale, every line and altitude being accurately delineated. We must congratulate the scientific world upon the addition of a book to its library so full of useful information, and we must also congratulate Dr. Percy upon the success which has attended his labours.

BRITISH POISONOUS PLANTS.

ILLUSTRATED BY J. E. SOWERBY, DESCRIBED BY C. AND C. P. JOHNSON. (SECOND EDITION.) JOHN VAN VOORST.

THE first chapter of this work, although it only contains four pages, is decidedly its most interesting and popularly useful portion. It treats of the nature of poisonous plants in general, and contains simple and practical directions for procedure in cases of poisoning before the arrival of the qualified practitioner.

Far be it from our purpose to terrify anxious parents by reciting any of the numerous cases of accidental poisoning in cases where persons have partaken of common plants; but we think they would be somewhat surprised, in glancing over the list, to find amongst them many that are considered perfectly harmless, and would keep a watchful eye upon their nursemaids and children.

The little work "owes its existence," we are told, to a case of accidental poisoning by a plant belonging to the buttercup (crowfoot) tribe. The common elder has caused death. The foxglove "is one of the most powerful of our indigenous poisonous herbs;" and (start not, youthful reader!) instances of poisoning by sorrel, or "greensauce," have *generally* occurred with children who had eaten it in considerable quantity.

The acid flavour of this herb, which is "in the mouth" of every child, is due to the presence of one of the most dangerous of vegetable poisons, namely, oxalic acid—which it contains in the form of binoxalate of potash; and it will be new to many of our readers that, "It is the above mentioned vegetable salt, obtained from common sorrel, that is now so generally met with in the shops of the druggists under the false name of 'essential salt of lemon,' for removing ink and other stains; a very small quantity of which acts as a powerful irritant poison. In one instance on record, a quarter of an ounce, administered by mistake, occasioned the death of a lady within eight minutes."

The whole book is full of interesting descriptions of poisonous plants, and we cannot do better than to extract a short one, as characteristic of the contents of the volume:—

"COMMON MONKSHOOD: WOLF'S BANE (*Aconitum Napellus*).— * * * * Every part of this plant is a powerful poison, and its action is often too rapid to admit of the effectual administration of remedies. The young leaves have been mistaken for parsley; the root on several occasions for horse-radish. The flavour of them both is totally unlike that of the vegetables for which they have been substituted, but this circumstance is either not attended to at the time or regarded as too trivial to excite more than a passing remark. The root of the monkshood has an earthy smell, and is bitter to the taste, without any very remarkable pungency at first, but soon produces a slight tingling and a burning sensation, attended with a kind of numbness and contraction of the skin, of the tongue, and roof of the mouth,—the pricking or tingling soon extends over the body and a feeling of constriction about the throat, occasionally amounting almost to strangling, induces the patient to frequently grasp it with the hand. The symptoms may vary according to age, constitution,

and other circumstances; but headache, confused vision, restlessness, convulsive clenching of the hands and jaw, vomiting and diarrhœa, attended with severe pain in the abdomen, are the most prominent and ordinary. The time of death varies from one to eight hours after the poison has been swallowed, and hopes may be entertained of the patient's recovery if the fatal termination does not ensue within that period.

"The monkshood was introduced here as a garden ornament, or, more probably, as a powerful medicinal agent, at a very early period, and occupies at present a place in our 'Materia Medica,' or catalogue of remedies sanctioned by authority. It has no other claim to be considered as one of the wild plants of this country than that of being met with growing uncultivated in a few places in the western part of England. Its frequency in the garden, and the careless manner in which its deadly roots are often distributed, have induced us to place it, though only an interloper, at the head of our list of British poisonous plants. The recent accident in Scotland, where three persons died in consequence of the roots of the monkshood being brought in by a boy from the garden as horseradish, and used by the cook, unconsciously, in preparing sauce for beef, added to many others of a similar kind, ought to render gardeners cautious in planting, and teach them to avoid placing this and other poisonous herbs in the vicinity of those employed for culinary purposes; and no less so in their disposal of superfluous roots where there is a possibility of their being found by ignorant people and misappropriated.

"The education of the gardener himself, however, is, in too many instances, inefficient, as, even when well acquainted with the names of plants and the methods of successful cultivation, he is often altogether destitute of information regarding their properties and uses. * * "

Mr. Sowerby's plates are very beautiful, and we need not hesitate to say that, if anything, they surpass the text in excellence. This edition of the work contains four additional plates and descriptive text of the principal poisonous Fungi of Great Britain.

As to the publisher's share in the work, we shall only say it is a book after Mr. Van Voorst's own pattern; and the beautiful coloured illustrations render it very suitable for the drawing-room table.

A Manual of Structural Botany. By M. C. COOKE. Hardwicke.

MR. COOKE has compressed into the smallest possible space, and the publisher has produced, at the lowest cost, all the information necessary to enable a teacher to instruct a class in the principles of botanical science.

An excellent feature in the little manual is, the explanation which accompanies every technical term; and especially in the case of the chemical substances, which are very clearly explained; as, for example:—

P. "Phosporus (Phos, *gr.* light; phero, to bring) is not found pure in nature; it is extremely inflammable, and emits, by slow combustion, a faint light visible in the dark. It is found in combination with those compounds of plants which contain nitrogen. During decomposition, phosphorus and sulphur enter into combination with hydrogen, and form phosphuretted and sulphuretted hydrogen; with metallic bases phosphorus forms phosphates."

Why the terms kalium, natrium, ferrum, and cuprum, are not given in explanation of the symbolical letters attached to the respective metals we do not understand; and we doubt whether it would not have been possible to find a more elegant and equally accurate translation for the word bromos than the

one given, but which we shall not repeat. The woodcuts, 300 in number, are clear and well executed, and will no doubt be useful to teachers in the preparation of diagrams and black-board sketches. Indeed, the book is one of the cheapest shilling-worths that we have met with, and deserves a large circulation.

Manual of British and Foreign Plants. By L. H. GRINDON. Pamplin.

THIS little work, which is a vocabulary of the scientific and familiar names of almost every known plant, including those "celebrated in literature, mythology, and holy writ," just reached us in time to test its efficacy, inasmuch as we were desirous of ascertaining the names of some rare exotic plants, of which the seeds are imported into this country for industrial purposes.

We found it exceedingly valuable for our purpose, and, having experienced its advantages, we can unhesitatingly recommend it to botanical students and collectors.

The Threshold of Chemistry. By C. H. HEATON, F.C.S. Chapman & Hall.

AN excellent handbook for beginners whose circumstances will not admit of their incurring much expense in entering upon the study of chemistry.

The definitions of the elementary terms are clear and good, and the illustrations useful in aiding the student to perform the necessary experiments.

There is, however, an absence of information as to the processes by which metals are obtained from the ores—a want which might have been supplied in some instances by the addition of a few lines. Mr. Heaton has deviated from the usual mode of classifying the metals; and his alteration appears to us to be anything but an improvement.

The book is an excellent one for teachers employed in the instruction of a class.

Elementary Treatise on Physics—Experimental and Applied. By Professor A. GANOT. Translated and Edited from the Ninth Edition. By E. ATKINSON, Ph.D., F.C.S.

OUR space will only admit of our noticing the first part of this excellent work. It is very clearly written, and freely illustrated with woodcuts. The definitions are in nearly all instances very clear and simple, but some objections may be made to the "general notion" of "matter," given in paragraph two, as being "that which possesses the properties whose existence is revealed to us by our senses," because this notion would include the *forces* of nature, viz., heat, electricity, &c., which, as well as matter, "possess properties whose existence are revealed to us by our senses."

The instances used as illustrations are also, in nearly all cases, very good, but in paragraph thirty-five, where a "hurricane" is spoken of as "a small mass, moving with great velocity," a more correct illustration might have been employed.

The engravings in it are of a superior kind, and the printing very sharp and clear.

Elements of Natural Philosophy. 2nd Edition. By JABEZ HOGG. Bohn's Scientific Library.

TO those who are not initiated into the mysteries of physical science, and therefore require a book written in the simplest possible style, this volume will prove acceptable. It contains a very large number of important physical facts, stated in the most simple and popular language, and illustrated by a considerable number of woodcuts.

The information given in it is of a very reliable character, and in nearly all cases it is up to the present state of knowledge in the particular point under consideration; but in one instance, at page 386, the old method of obtaining oxygen, by heating black oxide of manganese red hot, is still given, although the much more convenient and easy method of obtaining it, from a mixture of chlorate of potash and manganese merely by the heat of a spirit-lamp, has long superseded it. Some qualification is also desirable to be made to the statement at page 9, that "no direct pressure will break glass, if it be supported from behind." The volume is particularly suitable for those who desire *popular* instruction in physics.

SCIENTIFIC SUMMARY.

QUARTERLY RETROSPECT.

ASTRONOMY.

Figure of the Sun.—A photographic apparatus has been projected by Mr. De la Rue, by which it is intended to obtain pictures of the sun, in order to examine whether its disc be really circular, and more especially to determine whether it is flattened at the poles. The Astronomer Royal, however, considers this question to be settled, and is of opinion that the proposed instrument would not add any information to our knowledge on the subject. The enormous mass of measures of the solar diameter recorded at Greenwich, and other observations, would, he holds, be more a test of the trustworthiness of the instrument rather than the reverse. In fact, from twenty-five years' observations at Greenwich of the horizontal and vertical diameters of the sun (where 2,487 measurements were made of the former and 2,694 of the latter), it has been found that the horizontal exceeds the vertical diameter by only one-tenth of a second of arc—a quantity almost imperceptible.

Missing Nebula.—The evidence in favour of changes of form, and variability in the light of nebulæ, has hitherto been regarded with considerable suspicion by astronomers. That a single star should fluctuate in brightness presents sufficient difficulties in the way of explanation—that a whole swarm of stars could be extinguished at one and the same time, and not only it, but a distinct star in its neighbourhood—presents obstacles which are almost insurmountable in the actual state of our knowledge. The few nebulæ which Sir W. and Sir J. Herschel found to be missing whilst engaged in their surveys of the heavens were very naturally attributed to wrong entries, or to the original body having been a comet, both of which mistakes might have easily occurred. Even Sir W. Herchel's assertion that he had *actually* perceived changes in the nebula of Orion between 1780 and 1811 (which was, as Arago observes, *avoir pris la nature sur le fait*), and when he made use of the same telescope on both occasions, was looked upon with doubt by his illustrious son, although it has been verified of late years by M. Otto Struve. At present there can be no further doubt concerning the actual disappearance of a nebula. The object in question was situated at R.A. 4h. 13m. N.P.D. 70° 50′, and was discovered by Mr. Hind in 1851. It was again independently found by M. Chacornac in 1854, and observed by M.

D'Arrest four times in 1855 and 1856. With a telescope of four and a-half inch aperture, he describes it as "very bright." The writer of this notice stumbled upon it in the autumn of 1855, whilst searching for De Vico's comet, and not finding it in any catalogue of nebulæ, observed it as the object of which he was in search, as it bore an exact resemblance to a telescopic comet. It does not appear to have been looked for until the last few weeks, when to the great astonishment of astronomical observers, it was found to have *completely disappeared*,—not the slightest trace of it being visible in the most powerful telescopes, and even a star which was situated near it had dwindled from the tenth to the twelfth magnitude. Such a phenomenon as this completely alters all the former ideas and received hypotheses on the nature of nebulæ, and from the reliable evidence on which it is founded precludes all chance of error in the observation. Whilst following this subject, the attention of those observers furnished with good telescopes might likewise be turned on the undermentioned nebulæ, in which changes of lustre have been suspected by D'Arres.

The "faint nebula" Herschel, II., 99, is now (1855) of 1st class (bright nebulæ).
" " Herschel, II., 101, " of 1st class "
The "very faint nebula," Herschel, III., 44, " of 1st class "
On the contrary :—
The "bright Nebulæ," Herschel, I., 1, 23 and 104 are now faint nebulæ.
" " Herschel, I., 62, is scarcely perceptible.
" " Herschel, I., 119, called "very bright," by Sir W., and "bright" by Sir J. Herschel, is at present very faint.

Solar Eclipse of December 31st, 1861.—The total eclipse was observed pretty favourably in the south of France and Italy, and the north of Africa, but the detailed accounts have not yet come to hand. Mr. Talmage, who observed the partial phase at Nice, states that Venus was visible (at 3h. 25m. p.m.), but that none of the brighter stars could be seen, and that there was a semi-circular streak of red light close to the limb of the sun, which gradually diminished to two abrupt points. M. Schmidt, the astronomer at Athens, was very unfortunate in endeavouring to catch a glimpse of the total phase (the sun setting fully eclipsed near Phlious), and his account of his expedition recalls the days of earlier Greece. On December 25th, he left Athens, travelled over the Corinthian Isthmus, where he saw the effects of the great earthquake of Aigion, and proceeded to Longopotamos over Kleonä and Nemea to Hagios Georgion on the southern foot of the Trinkaranon. On the 30th he ascended Polyphengos to about 1,900 feet, but met with nothing but rain, north wind, cold, and darkness. *Haud ignarus mali, disco*, &c. &c. The transit of Mercury across the Sun's disc on November 11th, was observed at Adelaide (Australia), by Mr. Todd, as likewise at Victoria and Sydney. No phenomena were noticed. At Malta the heat of the sun was so great on that occasion, that Mr. Lassell was forced to construct a covering to shield him from the sun. He repeatedly fancied the planet to be elliptical, and when the limb of the planet touched the edge of the sun, the former took a "pear-like" shape. The diameter of the planet as measured by

M. Secchi at Rome was 9,08 seconds, which is smaller than that given by the tables now in use. Professor Secchi proposed to take a few more measures of this element, but this, he says, is very difficult on account of the termination of Mercury's disc which seems to be very faint at the edges. Mr. Baxendell at Manchester noticed its shape when touching the edge of the sun, as decidedly egg shaped, the small end of the egg being next the sun's limb. The excessive blackness of the planet, as compared with the nuclei of the spots, was very apparent.

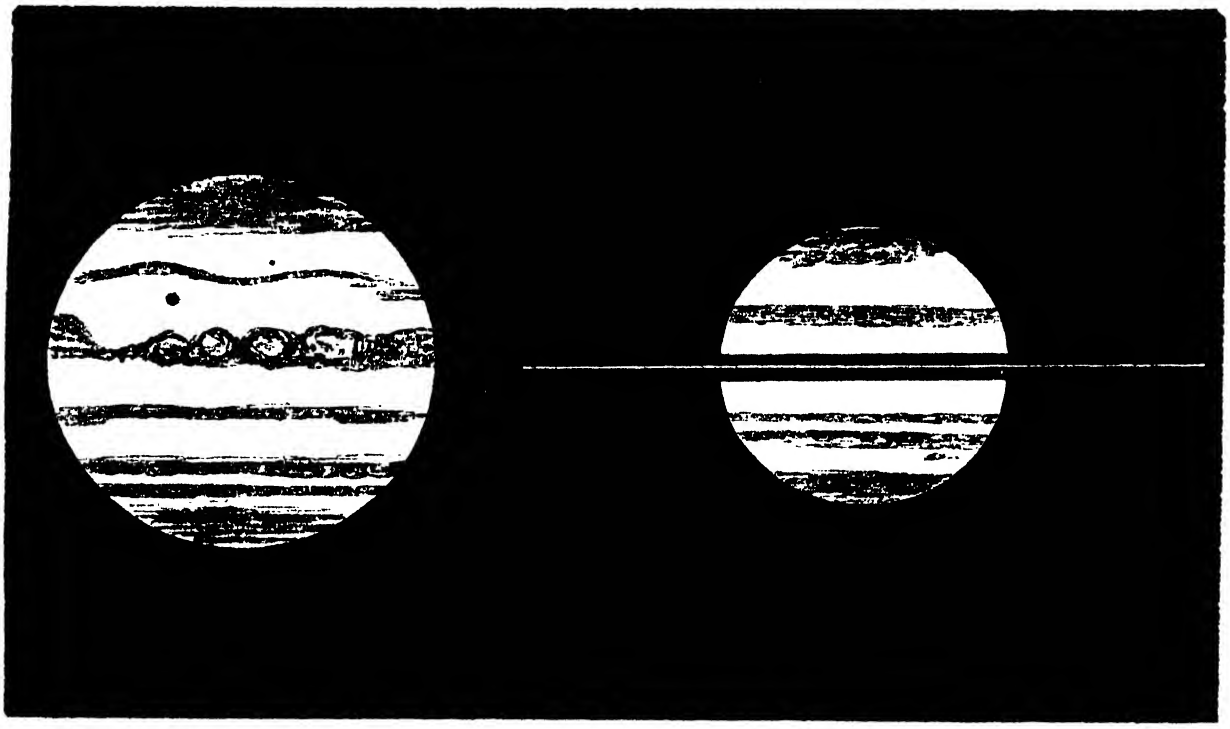
New Comet.—A telescopic comet was detected on December 29th, 1861, at 3 a.m., at Cambridge in the United States. It was independently discovered on January 8th, 1862, by M. Winnecke at St. Petersburgh. It was faint when first seen, and became much fainter subsequently. It was at its shortest distance from the sun on December 6th, being then at a little less than the mean distance of the earth from the central luminary. It approached within ten degrees of the pole star on January 20th. The great comet of July of last year was observed up to January of the present year. Astronomers must wait for the publication of all the observations, before its real orbit and true periodic time can be finally discussed. At present the latter element is doubtful—one calculator (Seeling) making its time of revolution round the sun 419¼ years, whilst another (Capocci) concludes it to be 1,796 years.

Meteors.—Within the present year, M. Petit, of Toulouse, has calculated the height of the great meteor of September 13th, 1858. He finds its height to have been 222 kilometres (about 138 miles), and its velocity per second 19 miles. That which was seen and fell in France, on December 9th, 1858, was only three miles distant at the time of the explosion, and its apparent velocity was about three miles per second. It was twelve minutes after explosion before its luminous train had disappeared and violent detonations were heard.

Saturn.—The ring of this planet disappeared duly (as far as most telescopes were concerned), at the calculated time. For some days previous to this disappearance, the thin line of light into which the ring had resolved itself was considerably broken, as if various irregularities existed on its surface. Captain Jacob on December 4th, 1861, with the new nine inch telescope constructed for him by Cooke, detected a thin white line of light crossing a dark belt covering the equatorial regions of the planet. This was independently seen a few evenings later by Mr. Buckingham, and on Mr. Wray pointing his telescope at the planet on the morning of December 27th, he was astonished not only to see this (which appears to be the edge of the ring,) but also the continuation of this line of light projecting beyond the margins of the planet in the dark sky. The appearance is given in the accompanying drawing.

The thin trace of light across the planet seemed like a knife edge and was broken. It does not appear that this phenomenon was previously witnessed, although looked for by the Cambridge and Pulkowa refractors sixteen inch aperture at the disappearance of the ring in 1848. It is a striking proof of the improvement of object-glasses of telescopes—for which we are wholly indebted to English makers—Messrs. Way and Cooke.

Jupiter.—This planet is now beautifully seen, and always varying in appearance, as far as regards its belts and spots. The *third* satellite was observed by Mr. Wray as a dark spot whilst transiting the planet, on the morning of December 27th. The *fourth* satellite has frequently been noticed in this manner. The principal equatorial belt was compared to a string of beads on this occasion. (See diagram.)



JUPITER AND SATURN.

As seen by W. Wray, Esq., F.R.A.S., at 6h. a.m., with a 7 inch Object Glass.

New Planets.—Between February 11th and August 13th, 1861, nine new planets were discovered. Since the latter date none have been detected.

Miscellaneous.—Mr. Lassell has erected his four-foot mirror at Malta, and is greatly pleased with its performance. He has detected a new star in the trapezium of Orion. The gold medal of the Astronomical Society has been awarded to Mr. De la Rue.

CHEMISTRY.

I. PURE CHEMISTRY.—Some curious illustrations of the *divisibility of matter,* which have recently been drawn from chemical and microscopic science, will aptly commence our retrospect of progress made during the past quarter. The results do not, it is true, throw any light on the long debated question as to whether matter is capable of infinite subdivision, or whether it is built up of an aggregate of almost infinitely minute, but yet

definite and indivisible atoms; but they carry the mind down towards the infinitely small until it is lost and bewildered in figures and quantities overwhelming in their minuteness, in the same manner that a contemplation of astronomical magnitudes transcends human comprehension in their almost infinite vastness. The illustration is derived from well-known properties of the metal gold. A sheet of gold leaf in its ordinary form has a thickness of about the $\frac{1}{282,000}$th of an inch, and weighs the $\frac{1}{37}$th of a grain per square inch. If one of these leaves be caused to adhere to a plate of glass (by breathing on the latter, and placing it on the gold), and a very dilute solution of cyanide of potassium be applied at the edge of the leaf, it will pass between the glass and the gold, and the latter will be perfectly stretched out, and floated on the saline solution. The solvent powers of the cyanide of potassium will now exert themselves; the gold will be gradually dissolved away, becoming thinner and thinner until a film of almost any desired degree of attenuation is left. At any moment the process may be stopped by washing away the cyanide by water; if then alcohol be used, and finally alcohol containing a minute portion of varnish, the gold film may be obtained, cemented to the glass plate. This method of reducing the thickness of gold-leaf we owe to Faraday; by its means the thickness will have become reduced to about one-twelfth part of what it was originally, weighing (in round numbers) the $\frac{1}{400}$th of a grain to the square inch, and having a thickness of only about the $\frac{1}{3,000,000}$th of an inch. In this state the film presents none of the ordinary appearances of the metal, being perfectly transparent and resembling a delicate film of pale green varnish, more than a dense metallic substance. Chemistry having given us this near approximation to a mathematical surface, how far can it be subdivided mechanically? By subdividing this surface after the manner of Nobert, whose test lines are well known to microscopists, a small grain of gold—a fragment scarcely larger than a pin's head—has thus been divided into three billion, eight hundred and forty thousand million separate pieces, each one of which is capable of being distinguished under the microscope! In order to enable our readers to form some faint idea of the significance of such overwhelming figures as these, we may state that the proportion which each square bears to the original grain of gold is about the same that a thimble does to a building five times the size of St. Paul's.

The difficult subject of chemical nomenclature, so formidable a stumbling block in the path of students, has been attacked by Mr. J. A. R. Newlands, who proposes the adoption of a system of building up the names of organic bodies, whereby the exact formula of any substance can be told from the arrangement and position of the letters and syllables of the word. The result of Mr. Newland's system is that Hoffmann's celebrated substance, Methylethylamylophenylammonium, will find itself transformed into *Bafyldahylharylkahylammonium*; no great advantage as far as length or pronounceability is concerned, but being useful, inasmuch as its name represents the mode of arrangement of its elements, as well as its formula and exact composition. The insuperable objection to this and all other attempts to remodel chemical nomenclature is, that they are simply incapable of being introduced. If chemists would

consent to throw away their present knowledge and go to school again, such concentrated essence of language might be useful, but under existing circumstances its partial adoption would be injurious rather than beneficial.

The phenomena of *phosphorescence* are well known to accompany many chemical changes. These have recently been studied by Reichenbach, who shows that phosphorescence, or the continuous emission of light in darkness, is a much more common occurrence than it is usually supposed to be. Thus there is phosphorescence during fermentation or putrefaction, crystallization, evaporation, condensation of vapours, the production of sound and the fusion of ice; a considerable glow is remarked when a galvanic pile in activity, a block of ice undergoing fusion, or a solution of sulphate of soda in the act of crystallizing, are observed in the dark. The human body itself is not devoid of phosphorescence; in a healthy state it emits a yellow glow, whilst in ill health the colour of the light assumes a reddish tinge. To perceive these phenomena, the eye ought to have been previously rendered sensitive by remaining for some hours in perfect darkness, and even then all eyes are not equally impressionable: if, however, several persons unite in performing the experiment together, there will always be a certain number who are able to perceive the phenomena. Those of our readers who remember the strange announcement made by Reichenbach some years ago, of the existence of a new force in nature, which he termed the odylic force, and have not forgotten the incredulity with which his statements were received, will be disposed to accept any similar observations *cum grano salis*. It must not, however, be forgotten that the propounder of these strange theories is one of the first chemists and physicists of the day, and his researches in this "occult" science are characterized by equal philosophical acumen with his chemical experiments.

The new alkali metals, the discovery of which by Bunsen, by means of "spectrum" observations, we noticed in our last number, have been proved by L. Grandean to be more commonly diffused than was at first imagined. They have been found in Vichy water, in the thermal waters of Bourbonneles Bains, and in many specimens of lepidolite. From the residues obtained in working 100 kilogrammes of this mineral, together with petalite and iriphylline, for the alkali lithia, M. Grandeau has prepared considerable quantities of the new alkalies, rubidia, and cæsia. They have likewise been detected in about equal proportions in some residues of the manufacture of saltpetre on a Paris refinery. In similar residues from Belgium saltpetre much rubidia, but no cæsia has been found. Chili nitrate of soda has not, however, been found to yield anything but soda and traces of potash.

Wittstein has verified Tyndall's observation that *pure water* is not colourless but blue. He has also established that the mineral matters which a water may contain do not affect the colour, but that the variety of tints, observed in different masses of water, are due to the presence of organic matter, held in solution by an alkali. He also finds that it may be universally accepted as a rule, that the browner a natural water the softer it is, and that it becomes harder as its colour approaches a pure blue.

A curious action of *silicic acid* has been noticed by J. C. Leuchs. He

finds that silicic acid, precipitated from a water-glass, produces fermentation in saccharine solutions, particularly after the addition of some tartaric acid, and generates the odour of beer yeast, afterwards of fruits, and finally of ether; in very dilute solutions, the odour of putrid yeast appears. Silicic acid does not lose this property by boiling with water, or by repeated employment for fermenting and subsequent washing with water.

The very rare metal *vanadium* has been found by H. Sainte-Claire Deville to be a frequent constituent of clay. In some researches on the mineral bauxite, he found that the colour which was thought to be due to the presence of chromium was, in reality, owing to vanadium. This led to a special search for this rare element, when it was found to be a frequent constituent of clay. It has since been found in clays from the neighbourhood of Paris, from Gentilly, and the refractory clay of Farges-les-Eaux. It seems, therefore, to be well established that vanadium may be found in most clays. Captain Caron has likewise found it in the emerald, in several natural aluminates, and in a very abundant iron ore found in the department of Cher.

The universality of the presence of *arsenic* is receiving stronger confirmation every day. C. L. Bloxam, the discoverer of perhaps the most delicate test for this element, has lately instituted a long series of experiments, in order to obtain sulphuric acid free from arsenic. Starting with the acid of commerce, which always contains arsenic, he successively tried distillation with chloride of sodium, passing hydrochloric acid gas through the boiling acid, electrolysis, fractional distillation, and distillation with oxydizing agents. None of these plans, however, would remove the acid. He then attempted to prepare the acid direct from sulphurous acid by passing a mixture of it and air over platinised pumice stone, but this yielded arsenic. Nitric oxide was then used to oxidise the sulphurous acid, but here arsenic was obtained from both gases. Lastly, he used carefully purified sulphite of soda, as a source of sulphurous acid, and a mixture of sulphate of iron, nitric acid, and sulphuric acid as a source of the nitric oxide. When these gases were prepared at low temperatures, the resulting sulphuric acid was at length found to be free from arsenic. It may be of interest to know that, amongst other bodies containing arsenic, common salt is included.

Silicium, the metallic basis of rock crystal, has been obtained, in a fused state, by H. Sainte-Claire Deville, and also by Captain Caron. It melts at about the fusing point of iron, and can be got in the form of bars and globules. A full account of the physical properties of this substance would be very interesting. At present, however, no full particulars have been made known.

The intensity and persistence of odour of some organo-metallic bodies are remarkable. One of the most striking illustrations which we have ever met with is afforded by a new body, *tellurium-methyl*, recently discovered by Dr. Max Heeren. If a small quantity of this substance is allowed to get on to the finger, it soon communicates a smell to the whole body, and in a few days is perceptible in the breath. The stench is so lasting, that the unfortunate chemist is shut out from society for several months.

II. Applied Chemistry.—We have alluded above to the almost universal distribution of arsenic. A remarkable instance of the presence of this element, in comparatively large quantities, in a drinking water, has recently been published. In the village of Bou-Chater (anciently Utica), there is a warm spring, which contains alkaline arseniates to the enormous extent of four grains to the gallon. The temperature of the spring is 40° C. It is clear, and has no unpleasant taste; the villagers drink it after letting it cool. The water flows from a basin about two yards in diameter. It is confined by stones, and there an old tortoise has taken up his abode, where he has lived from time immemorial, and is looked upon by the inhabitants as the genius of the place. The overflowings of the basin form a stream which, in the absence of a definite bed, spreads on all sides, forming a marsh of considerable extent, covered with rushes, Indian grass, and other plants peculiar to this kind of earth. The inhabitants make use of the stream for washing their linen and sheep's wool, and along the course of it their flocks of all kinds drink habitually. It is supposed that this spring is the same as that mentioned by Cæsar in his "Commentaries" as having such a terrible effect on the army of the Curio. M. Guyon, the chemist, who furnishes the analysis of the water, thinks that the spring was formerly more charged with arsenic than it is at present. It would be interesting for physiologists to study the influence which this water exercises on men and cattle, in reference to the recently raised questions on the economic action of arsenious acid.

The manufacture of saltpetre is being carried on to some considerable extent in America, and native chemical talent is being strained to the utmost to produce it in quantities sufficient to render the Government independent of foreign supplies. It is now being made in the States of Tennessee, Alabama, Kentucky, and Arkansas, from nitrous deposits collected in caves. The crude material of which it is made is a greasy, tough, yellow clay, having a saline taste. The caves in which it is found are very irregular; the best deposits being found in narrow crevices and dry localities amongst the rocks, where there are strong currents of air. It requires considerable experience to select the crude material. There is one establishment near Batesville, Arkansas, in which 1,000 lbs. of saltpetre are produced daily. It is not generally known that, during the previous war with England, saltpetre was manufactured in considerable quantities at the Mammoth Cave in Kentucky.

A curious calculation, of especial interest to makers, has been made by a continental chemist. It is considered, by the most reliable authorities, that the tobacco crop of the whole world amounts to 250 millions of kilogrammes per annum; taking the plant to contain an average of five per cent. nicotine, that would give 12½ millions of kilogrammes of this poison produced annually. The specific gravity of nicotine being a trifle greater than that of water, this quantity would fill 100,000 barrels, and would give 293 grains to every man, woman, and child on the globe. As a few drops will produce death, it is probably much within the mark to say, that the nicotine from one year's crop of tobacco would destroy every

living creature on the face of the globe, if its proportion were administered in one dose.

The repeal of the paper duty has caused a vast number of likely and unlikely materials to be employed in the manufacture of this necessary of civilized life. The curious mineral, asbestos, the long and flexible flax-like fibres of which used formerly to be woven into incombustible cloth, is the most recent ingredient used in paper making. Mr. Audesluys, the proprietor of considerable deposits of asbestos near Baltimore, has introduced asbestos paper in America with some success. From a specimen before us, it would seem well adapted for coarse purposes, owing to its very low price, but it is somewhat friable, although not more so than the commoner kinds of straw paper. The mineral is present to the extent of about thirty per cent., and communicates to the paper a not unpleasant satin-like aspect. It burns with a flame, leaving a white incombustible residue, which with careful management retains the form of the original sheet. Characters written on the paper with ordinary black ink are still legible after burning. Owing to the friability which the presence of this mineral communicates to paper, it would not probably be a useful ingredient in any except low-priced common paper, although it is not impossible that its peculiar property of resisting heat might be of use under some circumstances.

The powerful antiseptic properties of carbolic acid have long been known, but its extended use has been delayed owing to the difficulty experienced in obtaining it in considerable quantities. It is now, however, owing to the labours of Dr. F. Crace Calvert and others, to be obtained on a large scale, and this chemist has been the means of its application to many valuable purposes. As a medical agent it seems to have all the useful properties of creosote in an exalted degree, with some peculiar actions of its own, and is being applied with marked success in the Manchester Royal Infirmary and similar institutions, in cases of chronic diarrhœa, obstinate vomiting (even after creosote has failed), and as a disinfecting wash for ill-conditioned ulcers and gangrenous sores. It has also been applied in cases of foot-rot, which annually carries off large numbers of sheep. As the remedies hitherto adopted in this disease have been only partially successful, these experiments of Dr. Calvert, if they are confirmed in other quarters, will prove a great boon to farmers. The acid has also been applied in the preservation of gelatine solutions and preparations, of size made with starch, flour, and similar materials, and of skins, hides, and other animal substances. It also appears to act strongly as an anti-ferment, and Dr. Calvert states that it is one of the most powerful preventives of putrefaction with which he is acquainted. It is probable also that it may be found to protect timber from dry rot.

The same chemist has been investigating the subject of the preservation of wood in another direction, and has explained why so many of the recently-built gun-boats became rotten whilst others remained sound. The goodness of teak is ascertained to consist in the fact, that it is highly charged with a substance similar to caoutchouc; and it is found that if the tannin be soaked out of a block of oak, and it then be saturated with a solution of caoutchouc, it may thereby be rendered as lasting as teak.

Kœnig likewise has been investigating the same subject; the preservative action of sulphate of copper on wood has long been known, but several anomalies in its action required explanation. It is now found that the retention of copper in the pores of the wood is occasioned by the resinous matter present, those varieties which contain the most resin retaining the most metal; whilst woody fibre from which the resin has been extracted by alcohol fixes no copper whatever in chemical combination. The utility of sulphate of copper as a preservative agent may depend in a great measure on the resinous copper salt which is formed, and by which the pores of the wood are more or less filled up, so that the attacks of insects are prevented.

The valuable properties of *charcoal* as a means of absorbing and destroying the organic impurities in air by being filtered through it, have lately been applied on an extended scale to the ventilation of sewers, by Dr. Letheby and Mr. Haywood. The whole of the sewers in a space of fifty-nine acres in a crowded portion of the east of London have been for eighteen months past connected with the outer air by means of charcoal ventilators. The success of this plan has been perfect. Not only has all stench ceased from the ventilating gratings, but actual observation has repeatedly proved that the odour of the sewer gases is not perceptible when they have traversed the charcoal, and a chemical examination of charcoal which has been in use during the whole of the period shows that the organic *imasurata* is completely changed by its wonderful oxidizing powers into alkaline nitrates. Thus, by the agency of a little wood charcoal, the gaseous emanations of sewage, which the experiments of Dr. Barker, and the clinical observations of Dr. Murchison, have shown to be the cause of a form of continued fever, aptly termed *pythogenic*, are completely arrested on their passage up the ventilating shafts, and changed into perfectly innocuous compounds.

Now that paraffin oils are coming so largely into use, it may be of service to point out a very curious property which they possess. They seem endowed with a remarkable facility for ascending capillary tubes. When placed in a lamp the oil (especially the lighter varieties) rises rapidly on the wick, and flows over the outside, and sometimes even it will creep up the sides of a bottle containing it, and penetrate between the neck and the stopper, escaping into the air. When confined in wooden casks it readily permeates the junctions of the staves if at all unsound, and covers the outside of the barrel. As it is commonly the custom to export paraffin oil in wooden barrels, this property should be well remembered, or serious accidents will occur. It has happened already that in the hold of a vessel, where several hundred barrels of oil were closely packed together, the more volatile liquid permeated the pores of the wood, and mingled with the air, forming a highly explosive mixture, which, on the approach of a light, instantly ignited and set fire to the vessel.

The inalterability under atmospheric and most chemical agencies, which gave to paraffin its name, has been applied to considerable use in the laboratory of the chemist as a lubricant. Nothing is more common, and at the same time more annoying, than to find the stopper of some test-bottle obstinately refuse to move in spite of the different persuasive means

which experience has shown to be useful under such circumstances. By gently warming the glass stopper of a bottle, and then rubbing a little solid paraffin (not the liquid oil) over the contact surface, and afterward moving it round a few times in the neck of the bottle, both being perfectly clean and dry, there will never be any danger of the stopper sticking in its place. The strongest acid or alkaline solutions in ordinary use have no effect upon the thin film of paraffin, which forms the lubricant. Tallow or lard is sometimes used for this purpose ; but owing to the chemical nature of these substances they are soon attacked and rendered useless by caustic liquids, whilst the solutions themselves are injured by the introduction of fatty impurities. Neither of these objections applies to paraffin.

Some interesting experiments have lately been made by M. Maumené, Professor of Chemistry at Rheims, on the aëration of wines by different gases. Ordinary effervescing wine owes its sparkling qualities to the presence of carbonic acid gas, produced by fermentation, and dissolved in the liquid under a pressure of five or six atmospheres. The cork being removed, the greater portion of the gas escapes, communicating to the wine its much-admired sparkling qualities. M. Maumené has prepared wines by forcing oxygen gas into them, under a pressure of seven or eight atmospheres. The wine, when sufficiently old, undergoes no chemical change, even when kept saturated with condensed oxygen for more than a year, and the preparation of the oxygenated liquid is a matter of no difficulty. Wine thus prepared is much more sparkling, or foams more than ordinary champagne. When a bottle is opened it disengages pure oxygen, which rekindles the red-hot spark of a blown-out taper. The taste of the wine is not changed, but it produces, after being drunk, a very sensible warmth, like the better kinds of old wine, and a general and well-marked agreeable sensation. The employment for some days of oxygenated water as a beverage, produces an improvement in the functions of respiration and digestion. A curious result is obtained by charging wine with protoxide of nitrogen (laughing gas), instead of oxygen. The liquid so charged possesses, in a high degree, the power of producing the hilarious effects attributed to the gas itself, it having been found that it was only necessary to drink half a glass of wine, previously saturated with protoxide of nitrogen, at a pressure of six atmospheres, to produce the transitory intoxicating effects attending an inhalation of laughing gas. It is not improbable, that the powerful stimulating properties of oxygen gas, or protoxide of nitrogen, might be of considerable medicinal value, if administered in the convenient form of a daily glass of aërated wine.

New Manganese Dye.—An invention has been provisionally specified, by Mr. P. Morin, of Paris, which consists in the production of a green colour or pigment, by the treatment of oxide of manganese. Protoxide of manganese is transformed into a crystalline transparent substance, and takes a very rich green colour and diamond-like brilliancy when treated with hydrochloric acid in a gaseous state. The pigment or colouring matter thus produced may be applied to painting, dyeing, and the decorative arts, and may also be applied for industrial purposes.

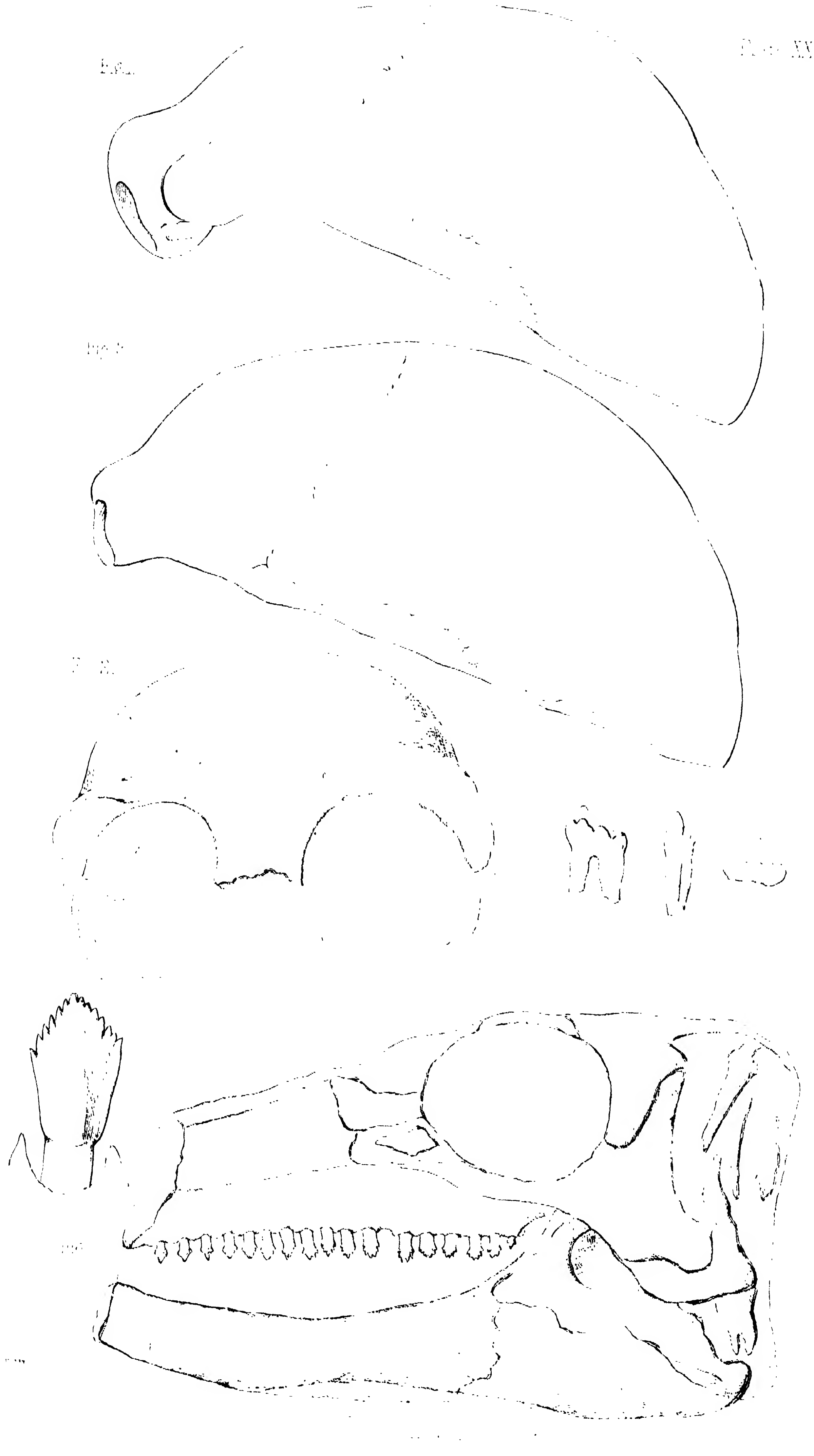
GEOLOGY AND PALÆONTOLOGY.

THE researches of the last two years have done much to prove that man may be regarded as a fossil form of life, as may the mammoth or mastodon. Accordingly, naturalists and geologists are everywhere busy writing our early history.

The fossil bones of man are not yet very numerous, and only one skull can be referred with any certainty to the date of the extinct animals of the Gravel period. It was found in a cave at Engis, near Lüttich, in Germany, associated with bones of the cave bear and other extinct mammals, all in the same state of fossilization, and covered by stalagmite. There is nothing very unusual about the skull except that the forehead retreats from the face with remarkable rapidity. But though this is the only specimen the great age of which is certainly proved, another human skull has been found in a cave at Neanderthal, between Düsseldorf and Elberfeld, which may be quite as old, and which is far more unlike the skulls of existing men. A side view of this specimen is given in Fig. 1 of the adjoining plate; and immediately below it, in Fig. 3, is an outline of the corresponding portion of the cranium of a young Chimpanzee. It can scarcely be necessary to insist on the near resemblance of the two forms. Fig. 2 is a front view of the human skull. In it will be noticed the very prominent ridges over the orbits; though not nearly so much developed, they resemble those of the Gorilla, and are a character commonly associated in old human skulls with a depressed forehead. This human skull is the most degraded form known, and makes the nearest approach to the ape's. Along with it were found a number of other bones; and these, too, differ much from the bones of existing men. The limb-bones are thicker in proportion to their length. This is a feature very characteristic of the higher apes. It also distinguishes the bones of children; so that, as we grow old, we put off the monkey. It is to Professor Shaaffhousen, of Bonn, we are indebted for a description of these remains. Sir Charles Lyell has verified the conditions of the cave in which the former specimen was found. Professor Huxley, remarking on the skulls, says that that from Neandersthal does not differ more from the Engis example than do the skulls of some Australian aborigines one from another.*

An account of another interesting cave exploration is given us by M. Lartet. Near the town of Auvignac, in the south of France, a small hollow on the side of a hill was accidentally discovered by a labouring man to contain about seventeen human skeletons. By order of the then mayor they were removed, and re-interred in the parish burial-ground; and in this translation were found a number of teeth of mammals, which,

* Although we shall unhesitatingly admit into our pages all reliable information bearing upon the early history of our race, and upon the origin of species, yet we wish it to be distinctly understood that we do not consider the time has arrived for the adoption of any of the contending theories on these interesting subjects.—ED. P. S. R.



on being sent to the well-known palæontologist, M. Leymeire, proved to be molars and canines of the hyæna, cave tiger, horse, aurochs, &c. This and other circumstances induced M. Lartet to explore the cave. Its floor and the space on the outside consisted of a deposit of bones of various carnivorous and herbivorous animals, of which most of those in the outer space have been split, as if for extraction of the marrow, and subsequently gnawed; and in the earth among these, various human bones and a tooth were met with, and throughout the mass a number of rude bone and flint weapons. Below all this was a layer of ashes, about six or eight inches thick, which did not extend into the grotto. The base of this old fireplace was made regular by filling in the inequalities, and had a partial paving with thin pieces of sandstone, now burnt red. Among the ashes were found cropolites of the hyæna, and the great bones of the rhinoceros and aurochs, which were split and gnawed, and often reddened and blackened by the action of the fire. Some of the bones have shallow cuts, as though made with the edge of some sharp instrument used to remove the flesh. And, singularly enough, there were found among the ashes a hundred flints, of which the greater number were of the kind called knives;* a few were sling-stones, rendered more than usually destructive by the number of their sharp angles. The part of the grotto in which the skeletons were found was closed by a large stone; and M. Lartet regards the people entombed as those who accumulated the bones, and remarks that none of the animal bones within the cave are gnawed, and were, therefore, probably deposited at successive interments. Be this as it may, there can be but little doubt that the date of the cave is anterior to that of the Amiens and Abbeville gravels, though the conclusion rests on more general principles than M. Lartet advances.

Danish naturalists, as a memoir by Mr. Lubbock tells us, have discovered that in very ancient pre-historic times their country was peopled by a race of Molluscophagi. These people, who used no weapons but rudely-fashioned flints, lived near the seashore, and have left evidence of their existence in deposits of shells so extensive that they were long mistaken for raised sea-beaches. The shells, however, are all full grown, and consist of species which are not naturally found together, being chiefly the oyster, the cockle, the mussel, and the periwinkle; and more rarely the whelk (*Buccinum undatum*), the hedge snail (*Helix memoralis*), and one or two others. Several fish are found; but chiefly the herring, the dab, and the eel. The most common mammals are the stag, the roebuck, wild boar, wild bull, and seal; and with them are found rude flint implements. Many of the bones still bear the marks of knives.† These heaps of refuse are known to the Danes as Kjökkenmöddings, that is, kitchen-middings, which, in fact, they are now proved to be. They vary in thickness from 3 to 5 to 10 feet, are sometimes nearly a quarter of a mile long, and 150 to 200 feet broad. Sometimes, however, instead of being formed about

* It is interesting to remark that the native Mexican barbers formerly used knives of obsidian to cut their customers' hair and beards.

† Every bone which contains marrow has been broken for its extraction.

villages, they are irregular rings, which have only surrounded a single tent.

At this period the pine was the common forest tree of Denmark; and with it is found the cock of the woods, which feeds chiefly on pine buds. With the heaps occur tumuli, which have supplied numerous skeletons. The skulls are round, and nearly resemble those of the Laps, but have a very prominent ridge over the eyes, approximating them to the form figured in the Plate. The front teeth do not overlap, but meet as do those of the Greenlanders. The age of these makers of the shell mounds is probably much more recent than that of the people of the caves before mentioned, but it still was, even measured by a natural history estimate, a very ancient period, for when these Danes ceased to work flint we find the pine-trees disappearing. These trees were succeeded by oaks, and with them came a race with differently formed heads, workers in bronze. And in their turn the oak-trees die away, and are replaced by beeches; and then comes yet another race of men, workers in iron,—a people whose tumuli tell of a long national existence before the Christian period.

The same divisions of time into the ages of stone, bronze, and iron, which were long ago well defined by ethnologists, have of late received excellent illustration in the explorations of the Swiss lakes. The bones of the men of the stone period as yet found are so few, that all we can say of their forms is that the people had round skulls. The tribes lived in villages on the borders of the lakes, and formed their habitations by driving piles into the bed of the lake. The trees vary in diameter from 3 to 9 inches, and in length from 15 to 30 feet, and some settlements have as many as 40,000. They penetrate into the mud about 5 to 11 feet, and have the lower end rudely pointed by the action of fire, and by stone hatchets. It is not quite certain whether the dwellings were perched on the top of these piles, or whether they floated on the water between them, though the latter condition is the more likely one. The cabins were built on a platform consisting of five layers of trees bound together by interlacing branches and clay. These dwellings appear to have been burnt, and it has so hardened their interior lining of clay, that it has been concluded from large pieces found that they were circular, and from 10 to 15 feet wide. All the species of animals which occur in the lake deposits, excepting the *Bos primigenius*, (the wild bull now extinct), are still found in various parts of Europe, though many have long since disappeared from Switzerland. Imbedded with them are a multitude of fashioned flints and other stones: chiefly hammers, axes, knives, saws, lance-heads, arrowheads, and corn-crushers. A rude kind of pottery occurs. A few domestic animals are found; and another indication of a civilization in wheaten cakes, and dried apples, and pears.

This stone age is probably of the same date as that of Denmark; the periods which succeed it are not so broadly distinguished from it as are those of the latter country, for the people still continued to build the "pile works" through the "bronze" period into the early part of the age of iron. Most of the remains are now covered by several feet of peat.

We are informed on good authority, that a collector at Woodbridge

has lately obtained from a deep digging in the Red Crag at Ramsholt two horns, which show marks of rude cutting.

In the Lithographic slate of Solenhofen, in Bavaria, Herman von Meyer has found the impression of a feather, which is not to be distinguished from that of a bird. No bones of birds are known of older date than the Cambridge Greensand, in which they are very rare; but the flying reptile, the Pterodactyle, is found in several species in the Bavarian representative of our Oxford Clay.

Professor M'Coy, of Melbourne, has found in the older tertiary deposits of Victoria a species of Trigonia. This genus of bivalve shells, which is one of the most characteristic fossils of the secondary rocks, had not before been found in the tertiary strata, though still living in the Australian seas. In the Silurian rocks of the colony the Professor finds the Graptolites and allied genera existing in many of the species which are found in Wales and Cumberland. And these same forms are found in North America and over much of Europe. Marvellous as so extensive a geographical distribution may seem, it must not lead to the inference that in the earlier ages of the world species were more widely diffused than now; for, at the present day, many of the common forms of similar existing Polyzoan zoophytes, such as Begula nevitina, Ætæa anguina, &c., are found on our own shores, those of Europe generally, along the American continent, in Australia, and in New Zealand.

It is not generally known that the remains of hot-blooded animals, mammals, have been found in the south of England, in a stratum even older than that which yielded the Seelidosaurus. Mr. Moore, of Bath, has found vertebræ and teeth of the Microlestes in a deposit at the base of the lias, called the Rhætic beds, which extend over much of Central Europe. The Microlestes, as will be seen from the figure (4), which is enlarged three times, has the characteristic mammalian dentition in the molar teeth having *fangs*.

Van Beneden has discovered that one of the peculiarities in which some of the Crag whales, such as Squalodon, differed from existing forms, was that they blew the watery vapour obliquely forwards instead of perpendicularly upwards.

The editor of the *Geologist* has figured some globular fossils from the lower chalk as fruits. They appear to have been drilled by the ship-worm (*Teredo*), and yet there is not a trace of structure. In the Cambridge greensand are commonly found spherical and egg-shaped bodies with apertures at the poles, such as there would be in a peeled orange were the central cord partially removed. An imaginative philosopher might make very many species of fruits out of those. They are possibly of vegetable origin.

Professor Ramsay has been investigating the origin of the basins of the Swiss lakes, and he finds that they each lie directly in the path of some great glacier; and, moreover, it is found that these, like the lakes of North Wales, lie in true rock basins, and not in hollows caused by subsidence or upheaval, nor in hollows scooped out by water, nor in lines of fracture; and, so exhausting all other possible causes, he shows that during a period when the glaciers descended lower than they do now these

lakes were hollowed out by the ice. The lakes are deepest at that end nearest the glacier; and in many cases their size and depths were shown to be proportionate to the size of the ice-stream.

Figure 5, is a greatly reduced figure of the Seelidosaurus, briefly noticed in the last number. Nothing further need be added, except to call attention to the reptilian character it shows well, with which most of our readers will be familiar, of having the lower jaw made up of several bones on each side, instead of one as in mammals. The hollow articulation of the lower jaw with the ball in the skull, which contrasts so with the reverse of the structures in the mammal, is unfortunately not shown.

MECHANICAL SCIENCE.

THAT wonderful work of engineering enterprise, the Mount Cenis Tunnel, is at last making satisfactory progress. Its entire length is to be 7·9 miles, and it presents the peculiar difficulty, that from the immense height of the mountain above it, no shafts can be sunk, and the whole has to be excavated at two working faces. At the beginning of last year boring machinery was applied, worked by compressed air; it consisted of eight drilling machines, making 200 strokes of 6 inches per minute; 70 holes about 3 feet deep were thus made in the face of the rock in six hours, and four hours were employed in blasting and clearing away the fragments. According to the latest accounts a new steam-machine has been applied, the invention and manufacture of Messrs. Hawkes, Crawshay, and Co., resembling a small locomotive engine, and carrying a large wheel on which are fixed a series of steel cutters intended to bore auger fashion into the rock, whilst the fragments dislodged are removed by rakes attached to the machine.

During March important experiments were made at Shoeburyness by the committee on iron plates, to ascertain if wood backing could be dispensed with in iron-cased vessels. The target had been constructed for the committee by Mr. Fairbairn, and consisted of 4½-inch armour plates of rolled iron, attached by 2-inch bolts to sheathing plates one inch thick, and these in turn riveted to very strong iron ribs. The armour plates were not dovetailed as in the *Warrior*, but depended entirely on the bolts, which, as the result showed, completely failed, the concussion breaking them in a most extraordinary way. The armour plates were therefore left at the mercy of the shot, buckled forwards, and might have been displaced if the firing had been continued. On the edge of two plates, that is, at the weakest part of the target, three of the heaviest Armstrong shot struck successively on the same spot, and the target was penetrated.

MICROSCOPICAL SCIENCE.

IN offering to the readers of the POPULAR SCIENCE REVIEW a *résumé* of what has been done in microscopical science during the past few months, it must be borne in mind that a selection only can be made from the most

interesting and important discoveries and observations which have been recorded—the crowd of intelligent observers being, on the one hand, so numerous, and on the other the space afforded in these pages being necessarily so restricted.

It will be best, therefore, to adopt as systematic a plan as possible, and we propose to divide the subject of microscopic research into animal, vegetable, and mineral; while any improvements or advances made in the microscope itself will not be lost sight of.

The advantages of the binocular microscope, upon which we dwelt in a previous article, are becoming generally appreciated, and a writer in the *Quarterly Journal of Microscopical Science* (Mr. W. U. Whitney) speaks in raptures of the new views of circulation in a little tadpole unfolded to his sight by the magical instrument. Having ingeniously rendered the little tadpole unusually transparent by a low diet, consisting of *clean* water only, Mr. Whitney was enabled to trace the direction of the course of the larger vessels; and was also favoured with a specimen, unusually transparent, which gave admirable views of its internal economy. We have not space to trace here the whole circulatory system in the tadpole, but wish rather to call attention to the interesting results at which the observer arrives. The first large artery which arises from the heart (the cephalic) supplies the head, but also "receives into it small branches from the subdivisions of the pulmonary artery, so that there is a direct communication between these two vessels." The second (pulmonary) trunk is devoted to the lung, for purposes of aëration solely; and the third (aortic), in its passage to the abdomen, inosculates with the pulmonary branches, and thus provision for aëration is much more completely made than in any reptile. The writer concludes that the liveliness and activity of the tadpole, so superior to that of the adult frog, are owing to this respiratory arrangement, on the well-known physiological principle, that the activity of vital functions is in proportion to the completeness of the aëration of the sanguineous stream which is sent from the heart to all parts of the body.

The changes which the juvenile frog undergoes require indeed active respiration for their normal production. For nine days after the animal is hatched he has external branchiæ like a fish, and requires, in this condition, to be placed in shallow water, not far from the atmospheric air. From the seventh to the ninth day these branchiæ rapidly vanish, first on the right side, afterwards on the left; and then the true tadpole swims apparent. Henceforth he requires atmospheric air for his active respiration. The question whether light or heat most favours the development of these changes forms the subject of a paper read before the Royal Society, by Mr. John Higginbottom, F.R.S., in January last. Numerous experiments, in which the frog's spawn was placed in situations whence light was excluded, led him to the conclusion (contrary to that arrived at by Dr. W. F. Edwards, of Paris) that, the *temperature* being sufficiently high, it mattered not whether *light* were present or absent, the ova developing with equal rapidity in either case. According to Mr. Higginbottom, it is the necessity for atmospheric respiration, rather than the presence of light, which causes the tadpoles to approach the surface, so that experiments, in which the tadpole were immersed in the dark some feet below the surface were altogether inconclusive. Pulmonary respiration takes

the place of branchial; and atmospheric air is necessary, without which the change from tadpole to frog cannot be effected.

We are all, as children, familiar with *spiders' webs.* To some they are objects of terror, to others of curiosity, and to a few, of attractive pleasure. How the little "curious fly" is suddenly arrested when his "gauzy wings" touch that fatal barrier! There is no escape, and out rushes *webspinner* to his dinner. Our friend Mr. Richard Beck has lately paid some attention to the nature of the viscid lines which thus entrap unwary insects, and read a a paper before the Microscopical Society lately, upon that subject. The beautiful regularly-formed webs of the geometric spiders are dotted, except in the closely-packed central fibres, with minute drops, which Mr. Blackwall has calculated the spider to produce at the rate of 200,000 in an hour. Mr. Beck, watching the little architect with a lens, observed that when the thin web left the spinnaret, although viscid, no dots were apparent. More close examination with the microscope rewarded the observer with a sight of the changes which the viscid threads underwent. At first slightly thicker than ungummed threads, the viscid secretion soon began to form undulations, and eventually separated, forming globules, by molecular attraction, at very regular and very minute intervals. Hence, while the wonder of the construction is in no way diminished, the incredible number of these little globules is accounted for by the supervention of a physical law, after the sufficiently marvellous organic law has fulfilled its purpose.

During some microscopic examinations, Mr. Attfield has discovered some new species of acari, which feed upon extract of *nux vomica.* In order to ascertain whether these curious little insects, which greatly resemble cheese-mites, really eat the strychnine, or only lived upon the starchy matter of the extract, some were collected and placed in two cells, one of which contained powdered strychnine, the other being empty. The acari in the empty cell were starved to death in a few days, whilst those with the strychnine were as lively as ever. Other new species of acari were fed upon other poisonous extracts. Those from colocynth thrived equally well on strychnia, colocynth, or cheese, but cheese-mites were poisoned when fed upon strychnine.

But if spiders, with all the wonders of their constructive skill, are, after all, but doubtful favourites, there can be no doubt concerning the attraction which the gay and careless *butterflies* possess for all ages, and for the scientific and the unscientific alike. The delight caused by the magnificence of their wings as they flit about in the sunshine only gives place to wonder when those wings are placed piecemeal under the searching microscope, and the innumerable feathers of which they are composed, far outrivalling in number and brilliancy those of the paradise-bird, gives one a feeling of revelling in the richness and prodigality of bounteous Nature. It would be more proper, in scientific language, to call them *scales* than feathers, for scales they really are, as the term Lepidoptera, or scale-wings, indicates. In the "Annales des Sciences Naturelles" is an article * on the wings of Lepidoptera, by Bernard Deschamps, from which it appears that these scales are composed generally of two or three membranes placed one above the other,

* Translated by Mr. A. G. Latham, and read before the Microscopical Section of the Philosophical Society of Manchester.

on the upper one of which certain granulations are found, which form the colouring matter of the scale, and render it more or less opaque. On the second membrane, striæ frequently exist, consisting of rows of small parallel cylinders, like harp-strings, or lines of pearl-like granulations. Of these striæ there are often one hundred on each scale. The writer believes that there is a *third* membrane in all scales, although it often happens that only two are apparent, owing to the transparency of one of them. In diurnal Lepidoptera this third lamella has the property of reflecting rich and varied colours, more beautiful than those produced by the granulations on the upper membrane. The genus *Vanessa*, and more particularly the exotic species, are particularly enriched from this source ; nor are the nocturnal Lepidoptera wanting in this respect, the genera Noctua and Sphynx being examples of brilliantly-coloured insects, though they are far inferior to the diurnal species. The rich metallic blues and greens of some exotic species, such as Ulysses and Paris, arise from a peculiar arrangement of the striæ, the intervals between which are pretty regularly divided transversely into longish squares, each square having within it a funnel-shaped depression. Some scales have the property of dispersing transmitted light in a very beautiful manner under the microscope ; and a good example, easily met with, of such scales may be found in the Gamma Moth (*Plusia gamma*), in which these scales may be found forming the pearly or golden bands which are seen below their first wings on the inner margin, starting from the base. The presence of granulations on the upper membrane adds much to the richness of this optical effect. The result of these observations of M. Deschamps seems to be, that "the most brilliant reflections produced by the scales of Lepidoptera are due rather to the *arrangement of their lamellæ* than to the regularity and transparency of their *striæ*."

Professor Unger, of Vienna, has made a curious observation upon some powder from a brick found at Eileithyia, in the Thebaid, Upper Egypt. On examining it under the microscope, he found no less than eight species of plants, of which it was possible still to make out the species, and similar in every respect to species now growing in Egypt and Nubia. The age of this brick being between 3,000 and 4,000 years, it would not appear that that interval has had any marked effect in changing the vegetation of that country.

Mr. Thos. Davies, in the *Microscopical Journal*, has called attention to the unworked field presented by the employment of polarized light—unworked that is to say, in a proper scientific manner ; for to many so-called microscopists the exhibition of its pretty effects constitute the whole science, so far as they are concerned.

The most notable contribution to microscopical construction of late has been the universal achromatic microscope of Messrs. Smith and Beck. This microscope, described and figured in the *Microscopical Journal*, has for its first recommendation cheapness—the sum of five guineas bringing it within the reach of many who are separated by an unfathomable abyss from the splendid instruments which would cost almost a year's income to them. An instrument made by the most experienced manufacturers at so low a price is in itself an advantage ; but the chief merit in their invention is, that it is susceptible of numerous improvements and additions, which its possessor can, from time to time, make, as his limited funds permit. Thus a body may be

added, to which three eye-pieces and three object-glasses are attached, in such a manner that no labour is lost in setting up the instrument, or in making the necessary changes. A binocular body, with the necessary draw-tubes, may also be added, readily adjustible with little practice ; and, finally, a *stage with actions*, so that the instrument only needs polarizing apparatus, parobolic reflector, lieberkuhn, camera lucida, and micrometer, to make it equal to doing any work which the microscopist may be called upon to perform. In these days of elegance and design, it may be objected that the microscope which possesses these advantages is not so symmetrical as higher-priced ones, but we doubt not that the beauty and completeness of the workmanship will amply compensate for any imaginary deficiencies on that score.

MINERALOGY AND METALLURGY.

Mineral Produce of Italy.—The following valuable information, relative to the mineral produce of Italy, is derived from a report by the commissioners of jurors of the Exposition at Florence :—

Sulphur.—The annual produce of the sulphur mines of Italy is estimated at 300,000 tons, valued at thirty millions of francs. Sicily produces the greatest quantity, while the Romagna produces 8,000 tons.

Iron.—35,000 tons are produced each year. This is all charcoal iron of fine quality.

Lead.—The produce of lead is 7,000 tons. The island of Sardinia alone furnishes 17,000 tons of lead ore (Galena).

Copper.—Annual produce, 1,500 tons, obtained from the mines of Monte-Catini and Capanne-Vecchi, in Tuscany, Agordo, in Venetia, and the Vale d'Aosta.

Boracic Acid.—Two millions of kilogrammes (rather more than two pounds avoirdupois) are produced in Pisa. The works of Count Larderele yield 1,800,000 of these.

Combustibles.—The lignites (wood coal) produced do not exceed 60,000 tons per annum. They have no coal in Italy but the poor anthracite of the Alps.

Nickel.—The nickeliferous pyrites of the Alps yield 50,000 kilogrammes of metallic nickel annually.

Gold.—These pyrites (nickeliferous) also yield, by amalgamation, 500,000 francs in gold per annum.

Mercury.—Tuscany produces 3,500 kilogrammes.

Manganese.—1,000 tons a year are produced from the mines of St. Marcel and Frammura.

Antimony.—Tuscany produces more than 50 tons of antimony per annum.

The Aqueous Origin of Granite.—It is well known that Mr. Sorby, of Sheffield, some years since, called attention to the fact, that the quartz crystals in granite had hollow cavities which contained water. Mr. Alexander Bryson has been pursuing this inquiry, the whole of which tends to support this view. In a paper recently published, Mr. Bryson states his conclusions thus :—

"I found that the quartz of the porphyry of Dun Dhu, in Arran, was full of cavities contained in the doubly acuminated crystals of quartz, for which this remarkable porphyry is distinguished. I also discovered, in the doubly acuminated crystals of quartz formed in the saliferous gypsums of India, thousands of fluid cavities, and the quartz impressed with the gypsum; and as no geologist would hold that this formation was of igneous origin, and as the quartz was impressed by the gypsum, if not contemporaneous, must have been subsequent to it; and, as the same phenomena were exhibited in the porphyry of Dun Dhu, I am forced to the conclusion that the latter was as much aqueous in its origin as the saliferous gypsum from India."

The Gold Deposits of Nova Scotia.—In the month of March, in 1861, a man stooping to drink at a brook observed a small piece of gold among the pebbles at the bottom, and, having picked it up, searched and found other specimens. This occurred at a place about a mile eastward of Tangier river. Gold was subsequently observed in the quartz lodes on the western boundary of Lunenburg harbour; and Mr. Campbell, who commenced washing the sands accumulated on the sea-shore, was eminently successful in finding gold. This led to mining and washing operations on a considerable scale. The result of this has been the discovery of several extensive tracts of metamorphic rocks, in which veins of auriferous quartz abound, and of sands in which gold exists in remunerative quantities. The following are analyses of those two varieties of Nova Scotian gold:—

	Tangier Gold.	*Lunenburg Gold.*
Gold	98·13	92·04
Silver	1·76	7·76
Copper	0·05	0·11
Iron	trace	trace
	99·94	99·91

Meteoric Stone.—In 1857, a meteoric stone was seen to fall near the village of Parnallee, in Southern Hindostan. This stone has been obtained and sent to the Western Reserve College, Ohio. It has been carefully examined by Professor Cassels, who thus describes it:—

"Internally it is a mottled grey colour, having numerous circular spots of pure white. Throughout its recent surface are numerous brilliant specks of nickel, and distinct crystals of nickeliferous iron, with a good deal of iron rust. The meteorite is remarkable for the great amount of nickel it contains, nearly 17 per cent. The magnet abstracts 21·151 per cent. of magnetic iron and nickel from the powdered stone. A careful examination of the stone detected silica, lime, potash, soda, oxide of iron, sulphide of iron, oxide of chromium, oxide of manganese, iron, nickel, cobalt, copper, sulphur, and phosphorus."

The *Bessemer process* of converting crude iron into steel of fine quality at one operation is now acknowledged by its opponents to be a success. From specimens recently exhibited by Mr. Brockbank, it is one of the most plastic and manageable of metals, more so even than copper. It shows a remarkable degree of ductility, and can be bent, flanged, or twisted, either hot or cold, without annealing, and over a considerable

range of temperature, which is not the case with ordinary steel or copper. A plate of 18 inches diameter has been forced through a series of dies until it has formed a tube 13 feet long and $1\frac{3}{4}$ inch diameter, without any crack or flaw. In drilling a circular hole into a plate of Bessemer steel, continuous shavings are formed, whereas in copper, or any other metal, the shavings break into pieces $\frac{7}{16}$ inch long. These sheets of the Bessemer soft steel can be bent backwards and forwards hundreds of times without a fracture, and are almost as flexible as paper.

PHOTOGRAPHY.

WITH so many claims upon the wall-space of the International Exhibition, it appears that the Royal Commissioners have not been able to place at the disposal of intending photographic exhibitors so large an amount of accommodation as will fully satisfy all demands. They have devoted, however, no less than three thousand square feet to the exhibitors in this department; and we may confidently anticipate that the forthcoming display will contain the choicest results, and be characteristic of our English operators. M. Claudet, as the exponent of the opinions of a large section of our most distinguished artist photographers, has addressed a letter to the Council of the London Photographic Society, wherein he advocates the policy of organizing, without delay, an independent exhibition for the reception of such works as are necessarily excluded from the International building at Kensington, but which, if collected, would constitute in themselves a very complete and interesting supplementary gallery, likely to possess great attraction for a numerous class of visitors to the metropolis during the coming season. Independently of M. Claudet's suggestion, a committee of the South London Photographic Society have already announced the terms of a mutually advantageous arrangement which they have entered into with the Directors of the Crystal Palace Company. If this scheme can be carried into effect at Sydenham, it is proposed to devote a large space in the first gallery, immediately adjoining the central transept, to the purpose of a British and Foreign Photographic Exhibition; and in recognition of the efforts of those who contribute to this collection, it is intended to present to each exhibitor a season ticket, available for six months from the period of inauguration, which is provisionally fixed for the 15th of May.

Since the period of the last report, M. Joubert has accomplished much towards perfecting his process for transferring photographs to glass and porcelain. Some of the photo-enamels which that gentleman exhibited on a recent occasion were unexceptionable as works of art.

Great progress has lately been made also in the production of transparent photographs upon glass slides, suitable for exhibition in the oxy-hydrogen lanterns. Mr. England employs a dry-collodion process in which tannin is the preservative agent, and prefers the use of a solution of sulphate of iron for developing the image. The magnified representations of street-scenes in Paris are remarkably true to nature, from their having been the result of instantaneous exposure; and the pictures which Mr. England has taken of the Niagara Falls, and other famous illustrations of American scenery, are also highly successful, whether examined in the stereoscope or projected upon a screen.

The later results of Professor Graham's important discoveries in *dialysis*, which have reference to the differences observed in the passage of various liquids through porous membranes, have placed in the hands of practical photographers a new and valuable instrument. The dialysis will serve a useful purpose in effecting the separation of salts from highly-charged albumen and other liquids of a glutinous nature; it is only necessary to expose these mixtures for a short time to the action of pure water outside the diaphragm, when it will be found that the saline constituents have passed through the animal membrane, or the so-called vegetable parchment, without any appreciable loss on the part of the albumen. So complete is this separating action, that it has been suggested to employ such means in the analysis of compound photographic preparations.

Improvements in the construction of photographic apparatus have resulted in the manufacture of cheap and efficient *rolling presses*, by the aid of which a very superior surface may be imparted to paper in the form of the finished proof, or in any intermediate stage. Messrs. Bury Brothers, of Manchester, have succeeded in greatly reducing the cost of these machines, so that they are now likely to come into general use, and enable the photographer to dispense with the practice of sending away the proofs to be milled.

The construction of the Camera itself is likely to undergo alteration in respect to placing the means of adjustment for focus in front, instead of the usual sliding arrangement being worked from the back. Many contrivances have been suggested; among others, that proposed by Mr. Window possesses the advantage of rigidity from the circumstance of the dark slide entering that portion of the camera-body which is firmly clamped to the tripod stand. The ground glass is also permanently attached to the back of the camera.

Mr. Crookes has reported upon the comparative efficiency of a substitute for orange-glass. Muslin or other light textile fabric is coated with glue in order to close the interstices, and form a continuous layer of sheet gelatine; this being submitted to the action of a weak solution of nitrate of silver, and then exposed to the light, forms a compound which is impervious to all but the yellow rays, and being tolerably permanent and insoluble, is susceptible of application for laboratory windows and similar purposes. The facts which stand opposed to its general introduction is the brittleness, which unfits it for rough exposure, and the tendency to air-bubbles in the glue giving rise to small pin-holes in the fabric.

The announcement of a *new photographic process* by Mr. Emerson J. Reynolds, of Dublin, has given rise to much discussion, and to the assertion of counter claims of priority. Sir John Herschel, Mr. Burnett, Dr. Phipson, and others, appear to have employed the oxalate of peroxide of iron as a chemical agent, which suffers reduction to a proto-salt on exposure to sunlight, and is capable therefore of a photographic application. Mr. Reynolds proposes to develop upon paper the result of such exposure by treatment afterwards with ammonio-nitrate of silver, when a picture will be formed by the dark reduced silver partaking of the general character of a photographic negative. Sir John Herschel preferred chloride of gold for developing the image; and Dr. Phipson endeavoured to dispense with the use of silver by employing pyrogallic acid in conjunction with the permanganate of potash.

ZOOLOGICAL.

The earth, air, and sea, are peopled with inhabitants, to which systematic zoological works may be regarded as so many directories containing their names and addresses. But so numberless are their denizens, that it can be no matter of surprise that many should be overlooked and omitted from the earlier editions; so that a running supplement becomes necessary, to receive the names of new visitors which from time to time reveal themselves to the prying eyes of intruding zoologists, who scour over untrodden deserts, watch in lonely solitudes, and scrape the bottom of the deep sea, in the hope of bringing to the light of science some retiring creature which has hitherto eluded the inquisitive gaze of the ardent naturalist. Such running supplements are numerous, and are enriched by the labours of workers in many countries and in many departments; and it is proposed that the present article, and those which succeed it, should serve as an index to these supplements—bringing under the reader's attention the most notable of the distinguished strangers which are thus unwillingly and unwittingly rescued from the fate of "blushing unseen."

It might naturally be expected that the additions thus made to our knowledge of the animal inhabitants of the globe, after so long periods of research had passed by, should consist chiefly, if not exclusively, of the *smaller* terrestrial animals. There are, however, some large tracts of the earth's surface so little explored by the European, that we cannot assert that terrestrial animals equalling, or even surpassing, in size those with which we are acquainted, do not exist. Thus, circumstances have recently occurred which render it a matter of high probability that a colossal bird similar to the Dinornis, if it be not the Moa itself, still roams about in the district of Nelson, in New Zealand. The Government surveyors have more than once come upon footsteps which struck them with as much astonishment as did that of Friday surprise the solitary Robinson Crusoe—footsteps whose length was fourteen inches, and spread eleven inches, while the stride measured thirty inches; and this has happened under circumstances which left no doubt in their minds of their being but a few hours old. Erelong it may be hoped that we shall hear of the restoration of one of the marvellous and romantic links which connect us with an elder world.

But while we may feel surprise that such vast creatures, treading the same solid earth with ourselves, should have so long escaped us, we can feel no wonder that the boundless sea should yield from time to time new marvels stranger than those we are yet acquainted with. As Spenser exclaims, in the "Faëry Queene,"

> "So fertile be the floods in generation!"

while a common proverb tersely expresses the same fact, which says that "there are stranger fish in the sea than ever came out of it." The great sea-serpent is still a *vexata quæstio*; and while so much can be said by naturalists on both sides, it must inevitably be held to remain *sub judice*. The most remarkable sea-monster which the "unfathomed caves of ocean" have

cast up to the light of day for some time past, was an enormous cuttle-fish observed by the crew of a French ship of war, the *Alecton*, about 40 leagues N.E. of Teneriffe. This monstrous cephalopod was 15 to 18 feet long, with eight arms 5 or 6 feet long covered with suckers, eyes of enormous size, and *beak* 18 inches in diameter. It was estimated to weigh 4,000 lb. Unfortunately, it was not secured, although wounded and seized with a harpoon. As a balance against these vast additions to the Fauna of our globe, we must strike out one of the most considerable of our quadrupeds from the roll. In the year 1854, the indefatigable Dr. Gray, of the British Museum, described the horn of a rhinoceros, which was so remarkably curved, and so different from the horns of known species, that he founded upon it a *new* species, which he called *R. Crossii*. That excellent Indian zoologist, Mr. E. Blyth, has recently discovered, however, that the extraordinary horn in question is but the "well-developed anterior horn of an old male *Rhinoceros sumatranus*, the common species of these provinces" (Maulmein). So that the number of species of these great pachyderms must be reduced by the erasure of *Rhinoceros Crossii* from the list.

There is no division of the animal kingdom to which more numerous and systematic accessions are constantly being made than to the various orders of insects. It could not be otherwise, when we bear in mind the vast proportion which the insect world bears to the other divisions of animals. The insect collector has many things in his favour: there is endless variety, and endless novelty; no fear of exhausting the subject, and comparatively little labour in the preparation of his specimens. It thus happens that insect collectors, both in this and in foreign countries, are numerous and successful. Mr. H. W. Bates, the indefatigable collector in an inexhaustible field, continues to enrich science with his lists, the latest being that of Longicorn beetles in the valley of the Amazon. Angola, too, has yielded some new beetles belonging to the same division; and to the Weevils other collectors have swelled the lists in their respective departments—as for instance the fertile discoveries of Mr. Adams, among the Mollusca of the Sea of Japan, have most recently added many new species to the Acephalous division, as well as a long list of Opisthobranchs, belonging to the families Cyichnidæ, Bullidæ, and Phylinidæ; while Mr. J. Yate Johnson has carefully systematised the Sea-anemones of the neighbourhood of Funchal, the capital of Madeira, adding six new and remarkable species from his own researches.

But the additions to the British Fauna should not be passed over in silence, and we will briefly state, in conclusion, what new inhabitants of our own islands have recently come to light. The pages of the "Zoologist" faithfully record the occurrence of unusual visitors, chiefly birds, to various parts of these islands. Among them is mentioned a species of goat-sucker (*Caprimulgus ruficollis*), killed some time since near Newcastle. Dr. Gray announces in the "Annals" the addition to the British collection of the rare fish, *Diodon pennatum*, caught near Charmouth; and the second specimen found on these coasts. A continental beetle (*Eustica plicata*) has been met with at Stockwell; and new additions to the Lepidopterous Fauna are not unfrequent,—species of Gelechia, Tinea, and other insects, which will be, no doubt, duly collected and recorded by Mr. Stainton, in

the *Entomologist's Annual.* Several new Entomostraca, inhabiting chiefly the Firth of Clyde, and belonging to the genus Cythere, have been described by the Rev. A. M. Norman; as well as fresh-water species of Cypris and Candora from ponds in Durham. Dr. John Anderson describes and figures in the "Annals," a new species of *Holothuria,* dredged in Bressay Sound, Shetland, at five fathoms; and the same observer has systematised the genus *Sacculina,* which is found parasitic upon crabs, describing one species, *S. triangularis,* which he finds commonly upon the edible crab (*Cancer Pagurus*) of the Firth of Forth. Against all these additions, also, must be deducted a fresh-water mollusc (*Physa acuta*), lately described as having been met with in a brook near Bushy Park, the presumed discoverer of which, however, now candidly confesses it to have been an error.

Before closing this *résumé,* we would call attention to the valuable catalogue of the Zoophytes of South Devon and Cornwall, now in course of publication by the Rev. Thomas Hincks, of Leeds, in the "Annals of Natural History." The subject of British Zoophytology is one which needs careful revision, and we regard these papers as of great importance, and look forward with pleasure to the forthcoming work on British Zoophytes, which the same gentleman is preparing.

POSTSCRIPT.

Since our Astronomical Summary was completed we received from Mr. G. F. Chambers an account of the discovery of a new minor planet by Dr. C. H. Peters, of Hamilton College, Clinton, New York. It will take the number seventy-one (Niobe, discovered in August last, becoming seventy-two), inasmuch as it was discovered in May last, although only now made public. The same correspondent also announces the discovery, by Mr. A. Clark, optician, Boston, F.S.A., of a new star, a companion to Sirius. This was made with an improved instrument, which is likely to aid in the development of astronomical research.

We are compelled most reluctantly to defer the insertion of Professor Ansted's second paper on Caverns.

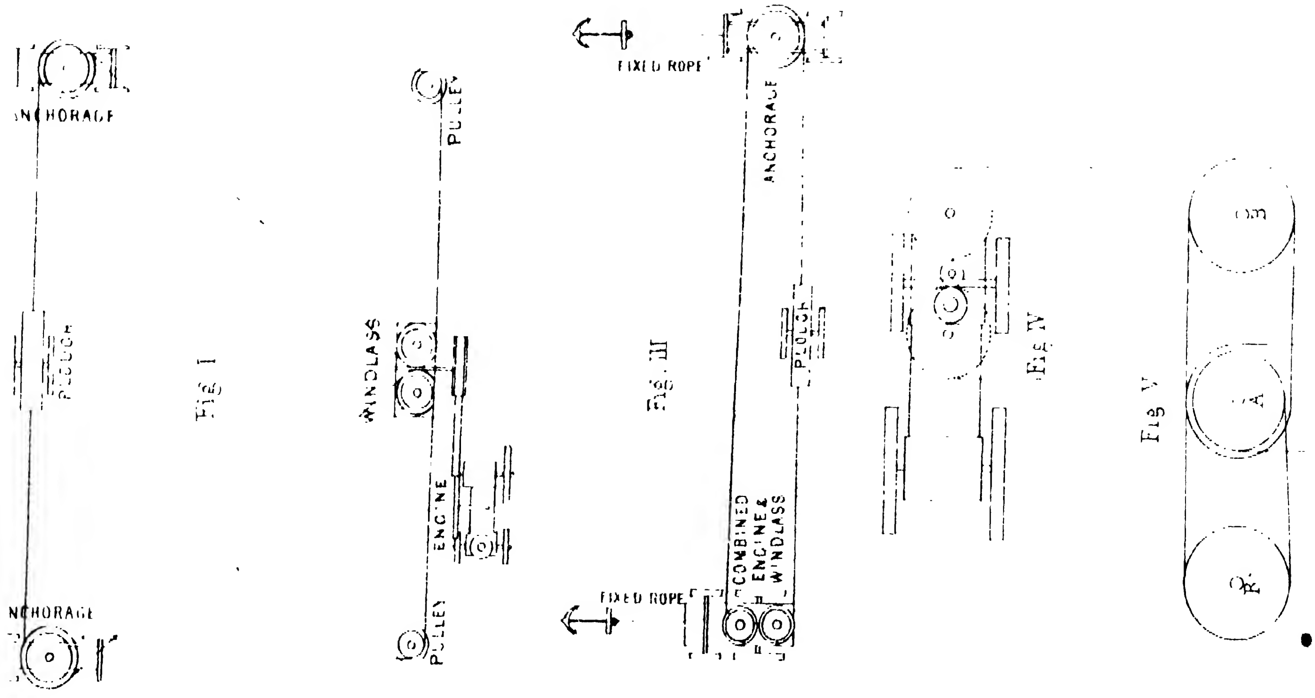


Fig I

Fig III

Fig IV

Fig V

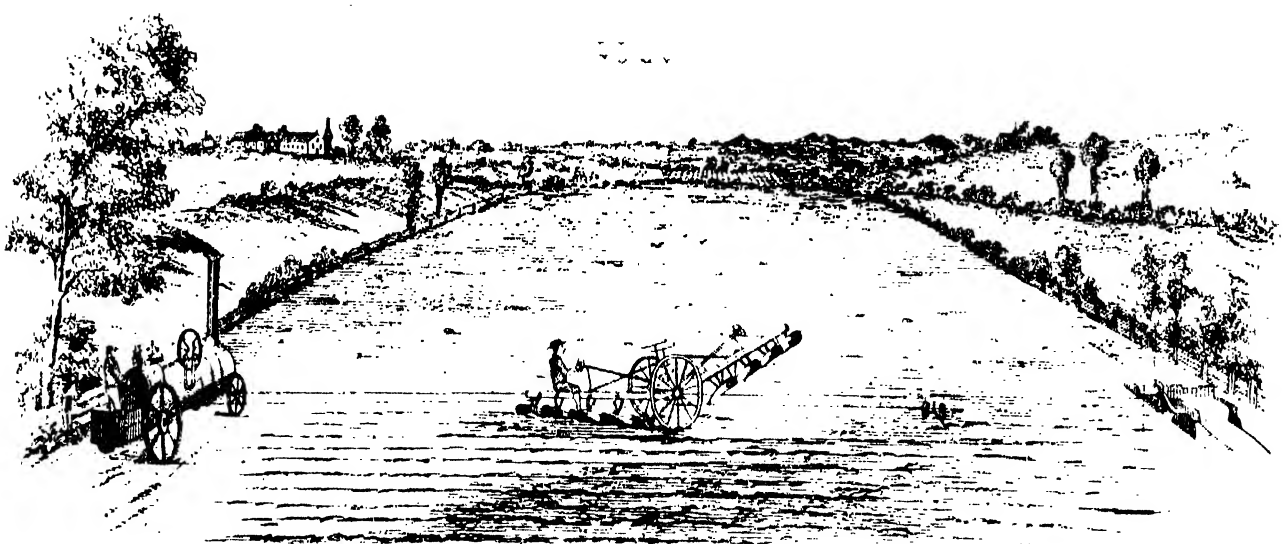


Fig VI.

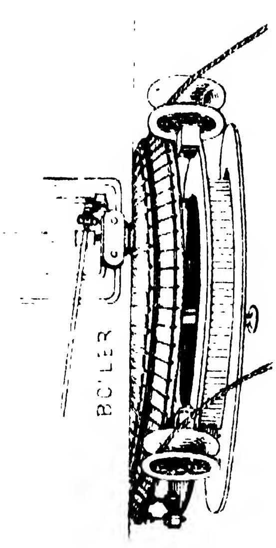


Fig VII

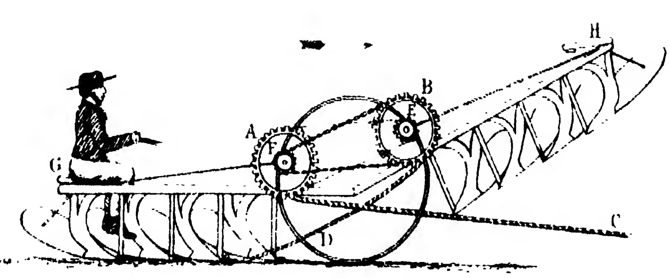
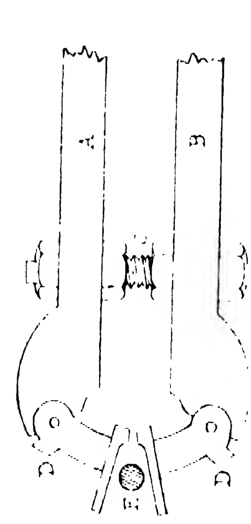


Fig II.



The Steam Plough

THE EXHIBITION OF 1862.

FEW of our readers who visited the Great Exhibition of 1851 will have forgotten the first effect produced upon their minds by the beautiful crystal edifice and its contents.

Strong men wept, they knew not wherefore; some were completely bewildered with the surrounding scene; and all who trod the maze of courts and avenues were glad, after a brief space of time, to seek some quiet corner and rest their wearied minds and bodies; for the multiplicity of novel objects, the varied costumes of the visitors, the grand arching roof of crystal overhead, the sweet-scented flowers and still sweeter strains of music, the wide-spreading trees in full leaf, crystal fountains, silent statues, sparkling jewels, and a thousand other attractions, riveted the attention by turns, drawing it first to this side and then to that, until the spectator walked as in a dream, and, unable longer to appreciate the wonders around him, sank down exhausted and satiated with the feast of beauty, grace, and novelty.

Since then we have had, and still retain, the Crystal Palace of Sydenham, far eclipsing that of 1851 in external beauty, and furnished with all the attractions of art and nature within and without its walls of crystal; the "Exposition" of Paris, concentrating within its precincts all the works of art and industry of which the Continent could boast. Manchester, Dublin, and other cities have followed in the wake; and now, after a lapse of eleven years, we are again called to the metropolis of Great Britain to witness the progress of the industry of mankind in a second "World's Fair."

But, alas! the fairy tale of childhood has lost its charm. The light Crystal Palace has given place to the solid edifice of brick and stone, and the directors of this new enterprise say to us, as plainly as they can speak through their brick walls: "You have been humoured and indulged in the fancy, now you must descend to the fact. Formerly we found it necessary to lure you through the senses, but now you are no longer children. A decade of years has changed the wants and tastes of your race, and you must therefore accommodate yourselves to circumstances, and be content to study the material progress of a utilitarian age."

With this view, then, the transparent walls of crystal are converted into impenetrable brick; light, ornamental iron arches give place, here and there, to temporary wooden ones, in order that more space may be afforded for the exhibition of works of industry; and everything, from the porcelain fountain to the solid refreshments, speaks of work—hard, earnest work, and its rich golden fruits.

But the contrast with the Exhibition of 1851 is calculated to remind the spectator, not only of the material progress which has been made in the interim, but also of sad events that have occurred since then, and of others which are now taking place.

We are sure the zealous noblemen and gentlemen who have taken so active a part in the execution of this work will pardon us; nay, they will, we think, agree with us, when we say that there is a falling off in the grace and harmony of the display, owing to the absence of one who combined the solidity of our nation with the taste which characterizes his own, and to whose intelligence the success of the first Exhibition was mainly due. The presiding genius of the place seems to manifest, by the carelessness of her attire, her esteem for the Prince who prepared her first palace and was removed before the second was ready for her reception.

Then there is another "absence" by which this great bazaar of all nations is rendered conspicuous. We miss (smile not, reader!) the long rows of Yankee hams, and pork, and cotton bales; ay, no one will deny that we miss those; the flour-barrels, full or empty, the heaps of gutta-percha soles and toys; we miss their rocking-chairs and their reaping-machines. For their cotton bales are now being employed to make bonfires, or to protect brothers from the murderous fire of brothers at home; and their reaping-machines are converted into scythes with which Death reaps his dread harvest.

Fortunately for us we have peace at home, although the casual visitor who saunters down the great aisle would hardly think so; for the display of rifled ordnance; of thick plates of iron battered by deadly missiles, and of small arms grouped in stars and pyramids, would lead the stranger to suppose that we were either on the eve of a great war, or had just concluded one of long duration. Nor would his surprise be diminished if he were told that all these terrible implements of warfare had been devised in order to enable us to maintain peaceful relations with a neighbouring people whose contributions to our Show are the admiration of all beholders.

Strange, then, and of a mixed kind, are the thoughts suggested by a cursory glance at our Great Exhibition of Industry, Science, and Art; but we must do the bidding of the "Com-

missioners," must cease to moralize, and take the world as we find it, encased in brick and stone. We must cast an inquiring glance into the Courts and Annexes—each an exhibition in itself—and endeavour to note the progress of the sciences. To do this as completely as our space permits will be our aim, and with this view we invite our numerous friends and contributors to send us their impressions, their NOTES OF THE EXHIBITION.

THE AGRICULTURAL IMPLEMENT DEPARTMENT.

BY HOWARD REED.

IN 1851 we well remember to have turned, with something of disgust, from the magnificent department where Russia displayed her malachite furniture, rich mosaics, and splendid tissues of gold and silver, to the bales of cotton, the maize, and pickled pork of America. They were strikingly opposed to one another, and it required some minutes before we could appreciate the force of the contrast. The sumptuous display in the one represented the gratification of the few; the vulgar but practical essentials in the other represented the comfort of the many. In the one we beheld the luxurious adornment of the palatial residence; in the other the solid comforts of cottage homes. As we gazed on the one, we beheld the means by which the land from Canada to the Mississippi had been subjected, cities raised as by enchantment, deserts peopled in a season, the whole country knitted together by iron ways, which cross the track of the Indian still fresh amid the dead leaves. The other spoke of popular stagnation, and recalled the lie with which Voltaire flattered and lulled Louis XV. in the midst of his court.

> Cette splendeur, cette pompe mondaine
> D'un règne heureux sont la marque certaine.

There will be found the same revulsion of feeling in favour of this pioneer force in the Eastern Annexe of the International Exhibition, although one does appear to be leaving all that is beautiful behind when penetrating the tunnel by which it is approached. When the mind is fully awakened to the utility of agricultural machinery, to the important part it plays in the subjection of the waste, the culture of much of the raw material which constitutes our wealth, and the production of food which supports man while he creates out of the raw material substances which contribute to our comfort or the forms which gratify our taste; the charms even of high art will be found

to possess a formidable rival in the homeliness of practical science in its working dress.

Here may be observed the drainer's tool, which has converted into a fertile field, the miasmic haunt where fever lurked, and whence he has made his deadly raids upon the neighbouring centres of population; here is the lineal descendant of the crooked Roman plough once guided by the good Cincinnatus, and which, improved in form, has upheaved the tenacious clays of England to the keen disintegrating tooth of frost and harrow, changing a churlish receptacle into a fertile seed-bed. Again, observe the automaton machine, which deposits the seed in regular lines at an equal depth, accompanied by nourishment suited to its earliest development. Near it, the implement which follows when the weeds appear, and lays low those enemies of the cereal blade. Then we have the iron reaper, with his keen swift sickle-edge, before whose radical progress the grain bends and falls for preservation when ripened by the sun of summer. And, lastly, behold the great steam-driven flail, which at once lashes the grain from its retreat and assorts it for use. These are but a few typical forms, but they suffice to suggest the part played by machinery in the great work of food-production, by which the country districts have been drained of their population. The last census shows a singular decrease in the simply rustic element. The wilds of Australia, the back woods of America, the gold-gains of auriferous regions, and the temptations of large wages in the mills, iron-works, and railway enterprises of our own country, have drawn Hodge from his quiet village in spite of the law of settlement, and yet the business of the farm goes on as well as ever. The area of land under cultivation is increased—its fertility augmented. Machinery has enabled us to effect the solution of an economic problem. Whereas in a savage state one man can barely obtain enough from the soil for the supply of his own wants and those of his family, we have, through the use of machinery, attained a state of civilization, in which the labour of *one* nearly suffices to supply the wants of *four* men, so that while one is retained in the field, three are sent to the towns to work for the World's Great Bazaar, and are supported while thus increasing the national wealth. The results, therefore, of human skill in other departments of this Exhibition may be regarded as directly due to the implements of husbandry here less attractively displayed, because they have set men free from the culture of the soil and the production of essential food, to minister to the more luxurious wants that always characterize the progress of civilized man. Preserving, then, a due sense of the relationship which subsists between the delicate tissues of the loom, the ennobling works of art, and the farmer's wheeled

plough—or, better still, the steam-drawn cultivator—a passing glimpse of the contents of this matter-of-fact section cannot fail to afford satisfaction.

About 140 manufacturers of agricultural implements have taken advantage of the opportunities here afforded to them for the display of their goods. All the principal firms are represented, some by a few main articles, others by a complete exhibition of everything made in their workshops. Here we perceive barrows, boilers, and bone-mills; carts, chaff-cutters, and churns; fire-engines, flower-stands, and forks; garden-tools, grinding-mills, and grubbers; haymakers, horse-rakes, and hurdles; mangers, mangles, and millstones; pails, ploughs, and pumps; rakes, reaping-machines, and rollers; scythes, spades, and steam-engines; thrashing-machines, tree-guards, and turnip-cutters; waggons, washing-machines, and water-carts; indeed, more than can be well enumerated.

But it is not our intention to follow this alliterative category. Were we to attempt it, there would be no great difficulty in showing that Progress is as well represented in the Eastern Annexe as in other departments of this World's Fair. A walk through this section will convince the visitor that its contents are not excelled elsewhere either in contrivance or workmanship, and those who remember the Agricultural Implements in 1851 will perceive surprising advances in several directions. Interest, for such reasons, may gather around the thrashing-machines, reaping-machines, the machines used in the preparation of food, engines, and the like, but it fairly culminates in *the Steam Plough*. It is doubtful whether any other section of the Exhibition can point to such an achievement as this. In 1851 there was no steam plough; there were drawings of impossible machines bearing that name in the Patent-office, and in 1855 scarcely a furrow in the country had been turned by this mechanical surprise; but now what crops of wheat and mangolds are sending down their roots and luxuriating in the deep steam-stirred subsoil! And all this accomplished in seven years! Think for a moment of the indomitable perseverance of the Buckinghamshire tenant-farmer Smith; of the courageous and inventive Fowler; of the sanguine Canadian Romaine; of Boydell, and Usher, and Williams, and the brothers Howard; of patents obtained and abandoned; of trials innumerable, public and private, and we have here such a story as the previous forty years could not tell, granting always that the progress of that period had much to do with the development of this.

In 1851 our progressive farmers were only beginning to think of the advantages of *autumn fallowing*, of the clearing of land during August and September, of its preparation for the early sowing of the root-crop, and had just discovered how

insufficient our horse-power was for such supplementary labour. Bentall and Coleman had furnished the desired land-parers, but we yet wanted the auxiliary force. Scarcely anybody at that period had conjectured the possibility of abandoning the dead fallow system, so long in clay districts a recognized process in all programmes of rotation; nor, indeed, was it until 1855 that the dawn of such a day was heralded to those advanced ones who are always watching on the mountain heights where the first streaks of light are visible. But, what a change have we now! We are at home with Fowler's steam plough and Smith's "smasher." The squire's horse takes no more heed of the engine traversing the headland than of the hare crossing the road; dead fallows are virtually abandoned; the clays are reclaimed; they are absolutely to be considered of some use to us, and the land now overshadowed by broad blade and glossy leaf, was cleared and laid up last autumn to be pulverized by the glacial influences of winter and fertilized by the free access of air and rain. This is a glorious, a highly poetical revolution; and it has occurred in less than ten years! Calculate, if you can, the effect which may be produced by the untiring toil of some two hundred of these steam-driven cultivators—ripping up the solid pavement made by the pressure of the horses' feet and the sole of the team-drawn plough, impervious alike to rain, and root, and air. A new mine is opened—or, in other words, the corn-growing area of our island-home is extended, doubled, trebled—not horizontally but vertically. You may search in vain for inventions in other departments of this Exhibition, likely to produce such singularly advantageous effects upon the future of our country.

We will not now enter upon the consideration of ultimate advantages, but will endeavour to narrate the steps which led to the present state of the rope-traction system of steam-tillage. It would occupy too much space to tell the whole history, taking our readers back to 1630, or beginning at a later date, rendered memorable by an enthusiastic inventor who induced several neighbours to part with their horses because he had designed a machine to supersede them. Such a trip into the past would be very pleasant, but we shall just fall in where Mr. Fowler, having solved the difficulty of draining land by steam, was quick enough to perceive that the attempt to do one thing had given him the power to do another, and that, though draining might be better done by men than by steam, ploughing might be performed more cheaply and conveniently by steam than horses. This was in 1855, when intelligent farmers were wishing for horses without feet, and implements that would work night and day during the critical six weeks of September and October. The windlass he used for the mole plough served

his purpose, so that he had only to invent a plough. A glance at the diagram (Pl. XXII., fig. 1) will show the windlass, which consisted of two drums on vertical axes, in a frame, set half-way down one side of the field, and driven by a portable engine. The two wire ropes led off from the drums in an angular direction to the anchorages, as represented, meeting in the plough. Each anchorage consisted of a low truck with four sharp disks instead of wheels, which cutting deeply into the ground, offered great resistance sideways, whilst they were easily pulled forward through the soil. A large sheave or grooved wheel was placed underneath, round which the wire rope passed, and the truck was weighted with earth to hold it firmly down. The ropes attached to the anchorages and passing round the pulleys at the corners of the field were so commanded by the men at the engine that the anchorages could be pulled forward by means of them, so as to be always opposite the work.

The "balance" plough, exhibited in 1856, continues pretty much as it was. It consisted of two sets of four plough-bodies rigidly fixed at opposite ends of a long beam-frame, which was balanced in the middle upon the axle of a pair of carriage-wheels (fig. 2). The hauling-rope, in this case attached a little below the centre, exerts force on the set of ploughs, on which the man is seated, in the direction of the arrow, while the slack rope dangles in the wake of those ploughs in order to pull the implement back and draw the opposite set the reverse way. The steerage was simply effected by a man riding on the implement, who was enabled to lock the axletree of the wheel. The anchorages in 1856 were made self-moving, so as to work without any dependence upon the men at the engine. Not many months after this, in 1857, an ordinary engine was placed upon the strengthened frame of the windlass, and the whole was made to traverse the field-headland by winding up a rope anchored forward. The machinery as it then was is represented in fig. 3. Let the engine be supposed to be entering one end of an oblong field with its train of apparatus. It makes its way to the opposite end. In one corner it leaves the anchor, and then proceeds to take up its own position in the other. The rope spans the distance between, and when steam is up, hauls the plough to and fro, the engine and anchor drawing themselves forward by the ropes anchored forward along the opposing headlands as the plough requires a new bite. Thus we see the matter simplified, and rope and power economized. The advance was certainly great, so much so as to merit the £200 prize offered by the Highland Society; but still the machinery was too ponderous and expensive for ordinary farm use.

Mr. Fowler in 1858 made another important step. His machinery underwent a complete revision. A new windlass

with two drums (fig. 4), each four feet in diameter, on vertical axles, and bearing upon their circumferences four grooves, had taken the place of the old one. Here was a fresh economy of rope and of power. In place of two long ropes which wound and crushed upon themselves in a manner which greatly injures metal cordage, there was established an endless rope, simply passing from the moveable engine on one headland of the field to the moveable anchorage at the other, but with a sufficient surface-grip in the drum-grooves already mentioned to keep it from slipping. The rope was divided into lengths, joined by hooks and eyes, and could be accommodated to the fluctuating length of the furrow. This apparatus has peculiar interest attaching to it. It decided at Chester the important case *Steam* v. *Horse-power*. *It established, in fact, for the first time, that steam is an economical substitute for horse-power*, and in so doing won for its inventor the prize of £500. The horse and the steam-drawn plough were tested side by side; upon light land there was shown to be a saving of 2*s*. 9½*d*. an acre, while upon heavy land the saving by the employment of the steam plough appeared to be 5*s*. 8½*d*. an acre. In the latter part of the same year it was found possible to dispense with one of these two drums, and to introduce the arrangement shown in fig. 5. The propulsion of one in place of two drums, beneath the frame of the locomotive engine, again economized power, or, in other words, coal.

At a subsequent period the implement was very much reduced both in size and price, and so lightened that whilst at the meeting of the Royal Agricultural Society at Canterbury, in 1856, it seemed content to grapple with two-horse work at a maximum rate of seven acres a day, it now made light of four-horse work at the rate of eleven acres, and executed that which was impracticable for horse-power at a maximum rate of six acres a day, drawing, at a much more rapid rate than horses could attain, three ploughs up hill and four down, and with a furrow that would require six horses to turn at their own pace.

We will now describe Mr. Fowler's apparatus as it performed last year at the Royal Agricultural Society's meeting at Leeds, where it was again distinguished above all competitors on the prize-list. Upon one headland or side of the field (fig. 6) is seen the engine; on the other the anchorage; the plough is between them. As the engine is the point of resistance, towards which the plough is hauled one way, so the point of resistance the other way is the anchorage. These two points, always opposite, gradually shift, little by little, from end to end of the field, the land between them being left inverted. The engine is of an ordinary character, but beneath its boiler it bears a large drum or wheel of peculiar construction, actuated by a

vertical axis descending from the crank-shaft. In order to pull a heavy implement, like a four-furrow plough, by means of an endless rope, which only embraces, but is not attached to a cylinder, it is clear that some ingenious arrangement is needed to prevent the rope from slipping under great strain. We have seen how this difficulty has been provided for; but we have yet to notice a better contrivance than those described. It had been found in practice that when the plough was in severe work the rope could not obtain sufficient hold of the drum-surface to overcome the opposing resistance, and thus, while the drum revolved, it ceased to afford motion to the rope. Instead of requiring a turn of the rope in grooves, this new drum grasps the rope in a single groove, the rope making but one half-turn round it (fig. 7). A common groove somewhat resembles the letter V in form. The power of such a groove to hold the rope against a heavy strain depends upon its nipping it. With this view, the drum consists of two iron disks bolted together—see section (fig. 8)—and the V groove is formed of pairs of knuckle-jointed nipping-pieces, so placed, in pairs, round their peripheries as to collapse upon the rope when it presses upon them. The anchorage has been described. Nothing more need be described with respect to the four-furrow plough save the ingenious method of keeping the rope always tight. (See fig. 2.) The advantage of such a contrivance will at once be seen by those who consider the difficulties that would continually arise from the varying lengths of furrows where hedgerows are not parallel.

We believe there are about one hundred of these steam-ploughs now at work in England, some tilling the light lands; but most of them rending the solid hoof-pressed pavement, which, beneath the cultivated surface of our clays, impedes alike the entrance of air, rain, and rootlet. In France there are several. Upon one farm in Hungary there are eight at work. Russia is employing them to bring her thinly-populated plains into cultivation. Our colonies possess them; in Algeria they are preparing a seed-bed for the cotton-plant, and even now two of them on the banks of the Nile stand face to face *with the common parent of all ploughs*. Here, it is displacing horse-labour, heralding improved methods of culture, and making provision for the demands of increasing population; abroad, it is fertilizing the waste, subduing prejudice, befriending the ardent and enterprising, and lending its shoulder to political revolution and national regeneration wherever they may be wanted.

It is no uncommon thing to find oneself rung out of the Kensington Exhibition before a tithe of the appointed work

has been accomplished; and now, ere we have even finished with the steam-plough, our remarks must be brought to a close. We have yet to notice the methods of steam-culture advocated by Mr. Smith, the brothers Howard, Romaine, Halkett; indeed, Mr. Fowler is scarcely done with, for no allusion has been made to the manner in which he adapts his apparatus, by means of a fixed windlass, to the requirements of those who do not wish to purchase a new engine specially designed to work the endless rope. But, in this particular, he has some decided improvements to show at the Battersea meeting, which, with other inventions, may well form the subject of our next communication.

DESCRIPTION OF PLATE XXII.

Fig. 1. The boundaries of a ten-acre field or plot of land are here represented. The *plough* begins at one corner of the field on the side opposite to the *engine*, and plies its course, taking four furrows forwards and four backwards between the *anchorages*, which are gradually advancing to the *pulleys*. When these are on a line with the windlass, the apparatus can be moved round to cultivate a similar plot on the other side of the engine, a hedgerow affording no obstruction to the passage of ropes.

Fig. 2. The following is an explanation of the automatic contrivance for gathering up the slack rope without loss of time. Two small drums, *a* and *b*, are mounted upon the plough frame, near the middle, the ends of the two wire ropes being wound several times round each, so as to allow of being paid out in case of a lengthening furrow, or gathered up for shorter work. Suppose the plough to be going in the direction of the *arrow*, the rope *c* will be the pulling rope, and *d* the trailing or slack rope. At starting, the rope *c* causes the drum *a* to revolve; by means of an endless pitch-chain this drives the pinion *e* on the axis of the drum *b*, which rotating with a velocity five times greater than that of the drum *a*, gathers up the slack rope *d* until the whole of the endless rope up and down the field is tight, when the rope *c* can no longer cause the drum *a* to revolve, and the plough consequently begins to move forward. In returning, *d* will be the pulling rope and *c* the slack; and by another pitch-chain the drum *b* must drive the pinion *f* on the axis of the drum *a*, so as to gather up the rope *c*. In order, therefore, to disconnect the pinion *e* from the drum *b*, and to connect the pinion *f* with the drum *a*, ratchet-clutches are employed, and these are ingeniously regulated as follows. Each pinion is held in clutch with its respective drum by a spiral spring upon the axis; but by a simple movement the clutch is released by depressing the seat at that end upon which the ploughman rides to steer the implement. Thus when the plough is proceeding in the direction

of the arrow, and the workman seated, as at *g*, the pinion *f* is free, and the pinion *e* in gear for driving the drum *b* more rapidly than *a* is turned by the rope *c*, and the seat at the other end of the plough is in the position *h*. On the return journey the ploughman sits upon the seat *h*, throwing the pinion *e* out of gear, and allowing the pinion *f* to drop into gear by its spring-clutch. In order to show the principle of this implement clearly, many details have been omitted, and the exact proportion of parts has not been strictly preserved.

Fig. 4. Here suppose the rope proceeding from the plough to take one and a quarter turn round the first barrel of the windlass attached to the engine, and another one and a quarter turn round the second, before passing in a straight line to the anchorage at the other side of the field, embracing the large grooved wheel there, and finding its way to the back of the plough from which it started.

Fig. 5. *a* is the drum mounted beneath the boiler; *b* and b^2 are loose grooved wheels or sheaves placed on either side merely to lead the rope round. The rope *x* will be found to take a three-quarter turn round *a*, a half-turn round *b*, a half-turn round b^2, and another three-quarters turn round *a* before striking off at *s* to the anchorage at the other side of the field.

Fig. 7. The "clip drum" is here shown beneath the boiler of the engine, fitted with internal teeth, and driven by spindle and pinion which are perpendicular to it. The barrel beneath is to carry any odd lengths of rope. The construction of the drum is further shown by—

Fig. 8. Which represents a section. *a* and *b* are portions of the upper and lower flanges, which can be adjusted to different distances apart by bolts and nuts, as at *c*; *dd* represent a pair of the clipping pieces hinged on to the respective flanges; the rope *e* is taken between them, and by its even pressure inwards causes itself to be nipped.

THE BRITANNIA AND CONWAY TUBULAR BRIDGES.

BY WILLIAM CAWTHORNE UNWIN, B. SC.

THE Chester and Holyhead Railway, planned with a view to facilitate the journey from Dublin to London by shortening the sea voyage, is one of the most remarkable engineering achievements of this eminently mechanical age, whether we regard the importance of a safe and rapid communication between the capitals of this country and the sister isle, or the magnitude of the difficulties overcome in accomplishing it. And the bridges over the Conway River and the Menai Straits, the boldest of the works on the line, derive a special interest from the novelty of the scientific principles discovered and applied in their construction.

Three great names cluster about their history, names of men who had already achieved a foremost rank, each in his own department, and who, as they shared in the labour, must divide the honour of success. Robert Stephenson, the engineer of the line, had first to cope with the problem of constructing bridges of spans never before attempted in railway structures, and under embarrassing conditions imposed by the Lords of the Admiralty, to preserve unimpaired the navigation of the Straits. To him belongs the merit of the first conception and courageous carrying out of plans which were elaborated chiefly by Mr. William Fairbairn, to whom was intrusted an experimental investigation of the laws of resistance of wrought-iron structures. Harassed by parliamentary business in the exciting period of the railway mania of 1845-6, Mr. Stephenson had not the leisure to mature his own project, and Mr. Fairbairn himself, distrusting his power of dealing with the more refined mathematical questions involved in designing such unprecedented structures, called to his aid Professor Eaton Hodgkinson, who had long been associated with him in similar researches, but who, though able and enterprising, was more cautious and less confident of success than were his coadjutors.

I. *History of the Original Conception.*—Speaking roughly, we may divide bridges into three classes:—1st. Arched

Bridges, in which the vertically acting strain of the load is transmitted as a force of compression causing a divergent thrust on the abutments. 2nd. Suspension Bridges, in which the pressure of the load is transmitted as a tensile strain along two or more chains which exert a convergent pull on the abutments. 3rd. Beam or Girder Bridges, in which the pressure of the load is resolved within the structure itself into two horizontal forces,—one of compression acting along the upper portion, the other of tension along the lower portion of the beam. In this case there is no strain upon the abutments, except a simple vertical pressure equivalent to the load and weight of the structure.

Mr. Stephenson's first idea was to employ magnificent cast-iron arches of 350 feet span, which, in the case of the Menai Straits, he proposed to construct, by a most ingenious method, without the aid of centering. The boldness of the project may be understood when we recollect that the largest cast-iron bridges then erected were those at Southwark and Wearmouth, of 240 feet span. To this proposal, however, the Admiralty objected that the navigation of the Straits would be seriously obstructed. They demanded that any bridge there should have spans of 450 feet, with a clear opening of 103 feet above high water for the passage of vessels. Requisitions such as these, against which there was no appeal, would have vetoed the undertaking to any one less conversant with railway difficulties than Mr. Stephenson. He, however, at once reverted to the idea of adopting the *suspension* principle. He had, indeed, first of all contemplated the strengthening of Telford's fine suspension-bridge which crosses the Straits with one large span of 580 feet, to adapt it to railway purposes, a project very soon abandoned. But now in his perplexity he returned to his first plans. Such a bridge has a perfectly level soffit,* can be erected without centering, † and of all descriptionsof bridges, had alone, at that time, been employed in great spans. It has, in addition, the advantages of lightness and consequent cheapness; but, with the counterbalancing defect of extreme instability, arising from the unequal expansion of the chain and roadway, and even more seriously, from a tendency to vertical wave-like oscillations, with high winds or suddenly applied loads. Of these defects Mr. Stephenson was fully aware, having had not long before to replace a suspension-bridge on the Stockton and Darlington Railway, which had utterly failed from these causes, the rails having risen up three feet in front of the engine when the

* The underside of an overhanging structure.

† The wooden scaffolding or framing employed to support arches, &c., during their erection.

trains came upon it. Nevertheless, he thought that rigidity sufficient to prevent this might be introduced in the platform, whilst the bridge still derived its main support from the chains. "If the platform be made rigid, then I think the suspension principle may be applied." So he stated before the Parliamentary Committee in May, 1845. This stiffening of the platform had to some extent been already accomplished in America, and by Mr. Rendel, at Montrose, by means of *wooden trussing*. Their plans were considered, but rejected, and Mr. Stephenson's great merit consisted in choosing a better material and selecting a better form. The rigidity of *tubes* had long been known; he seized on the fact, and applied it to solve his problem,—"there was no way" he found, "so simple, so cheap, or so rigid, as throwing *iron-work* into the form of a tube."

The idea of a rigid suspension-bridge was both original and valuable. Probably it was rightly abandoned in the case of the Britannia Bridge, because neither the experience nor the experimental knowledge necessary for carrying it out were then attainable, yet attention is now again directed to it, and one of the most remarkable railway bridges in existence is that which Mr. Roebling has erected over the Falls of Niagara, of a span of 821 feet, and combining rigid iron girders and suspension-chains. Indeed, there are only two ways in which we can much exceed our present spans,—either by the introduction of a stronger material than wrought iron,* or by the adoption of the suspension principle under some modified form.

But even whilst giving his evidence in May, 1845, Mr. Stephenson was wavering in his adherence to this principle. Still believing the chains to be necessary in the erection of the bridges and advisable as a permanent precautionary measure, he had begun to think of throwing the chief part of the strength of the bridge into the tube itself. Having abandoned the principle of the arch, he was faltering in his attachment to that of suspension, and was progressing towards the adoption of that of the simple beam or girder. This change in his views he attributes three times in the course of his parliamentary evidence to information supplied by Mr. Fairbairn, whom he had called to his aid about a month before.

Mr. Fairbairn had been engaged in iron-ship building, and had known cases in which iron vessels of 250 feet in length had been stranded at the extremities and left suspended, precisely in the condition of a bridge, with 1,000 to 1,200 tons of machinery in the middle, yet without injury. Relying on these

* Attempts have already been made to introduce milled steel for this purpose; and there is great probability of its being ultimately adopted when, by the new processes of manufacture, its price is sufficiently reduced.

facts, and having always had an antipathy to all forms of trussed beams, Mr. Fairbairn appears to have believed from the first that a simple tubular girder, without auxiliary chains, but of the form first suggested by Mr. Stephenson, would best meet all the requirements of the case. In this opinion neither Mr. Stephenson nor Mr. Hodgkinson concurred till a much later period; the former was determined "to have two strings to his bow" (both chain and girder), and the latter was sceptical as to the resistance of the tubes to compression. It is a curious fact in proof of this, that the Conway Towers, commenced as late as May, 1846, were built with the necessary provisions for the reception of the chains as originally designed.

II. *The experimental Inquiry.*—The general principles of girder bridges were already ascertained; the form of greatest strength in cast-iron had been determined by Mr. Hodgkinson; but of wrought iron much less was known. The strength and proper distribution of this material was, therefore, the subject which Mr. Fairbairn set himself to investigate in a series of experiments. He at once proceeded (July 1845), abandoning all reference to suspension-chains, to test the actual resisting powers and mode of fracture of various kinds of tubes. Cylindrical tubes, as the simplest, were first tested; then elliptical tubes, specially recommended by Mr. Stephenson; and lastly, rectangular tubes. The rectangular tubes were found to be decidedly the strongest, next to these the elliptical, and weakest the cylindrical. Thus the first of the distinctive principles of the bridges—the *rectangular form*, was at once deduced from the experiments; and the other was soon to follow. Almost all the tubes had given way by the crumpling or buckling of the upper part, as shown in Pl. XXIII., fig. 3. The resistance of thin plates to compression was evidently very inferior to their resistance to tension. It was necessary to strengthen the top, and this Mr. Fairbairn effected by means of a *cellular fin*. A tube was constructed of an ellipitical form and with a triangular cell at the top (Pl. XXIII., fig. 1), and the result was so satisfactory that a rectangular tube with two cylindrical corrugations or cells was at once planned (fig. 2). This tube (which obtained the name of the spectacle tube) was experimented upon October 14, 1845, and first combined the two novel features of the bridges. From this period every difficulty in the design of the bridges disappeared.

In March, 1846, the first definite calculations of the areas of metal in the Conway tubes were made, and a model was constructed of 1-6th the real dimensions, which was submitted to experiment with a gradual increase of area in the bottom until the resistances to tension and compression were precisely

balanced. These experiments finally determined the proportions of the bridges. The progress achieved by the experiments is shown by the following figures.

Comparative Strength of Tubes of the same weight, depth, and span.

Cylindrical	13·0
Elliptical	15·3
Rectangular	21·5
Model tube with cells	26·7

That is, the strength of the cylindrical tubes was more than doubled, with a better distribution of material in a rectangular form and with a cellular top.

III. *The General Form of the Bridges.*—The bridges ultimately erected consist of huge tubes or tunnels of wrought iron, spanning the water horizontally from pier to pier, and carrying a single line of rails within each, as shown in Plate XXIII., fig. 4, which is an elevation of the Britannia Bridge, and in fig. 5, which is a section across one tube at the centre. They are composed of rolled plates with longitudinal **L** iron bars, in each of the corners, and vertical **T** iron pillars or struts* to stiffen the sides, the whole being united by riveting. This construction will be explained by fig. 6, which is a section at one corner of the tube (fig. 5) on an enlarged scale. No auxiliary chains were used in the erection of the bridges, part of the tubes being built on scaffolding and the remainder on stages on the shore, whence, when completed, they were floated into their proper position and raised by Bramah presses.

The Conway Bridge has a single span of 400 feet, crossing the river close under the walls of Conway Castle, at a height of only seventeen feet above high water. Each of the tubes weighs 1,200 tons.

The Britannia Bridge is a much larger structure, having four spans, an elevation of which is shown in Plate XXIII., fig. 4. The entire length of each tube is 1,511 feet, and the length of the bridge, inclusive of the abutments, 1,841 feet, or more than a third of a mile. At the point selected for the bridge, the Britannia rock, uncovered at low water, divides the straits into two approximately equal portions (see fig. 4), on this the central, or Britannia Tower, was erected. On either side, at a distance of 460 feet clear span, two smaller towers were constructed on the strand; and again, at 230 feet distance from these, the Anglesea and Carnarvon abutments, each 176 feet in length. The towers are of very simple but massive form, suiting the simple outline of the stupendous structure they sustain. The Britannia Tower is 221 feet in height and 50 feet by 60 feet at the base. It contains 25,000 tons of

* The parts of a framed structure under compression.

THE BRITANN BRIDGE

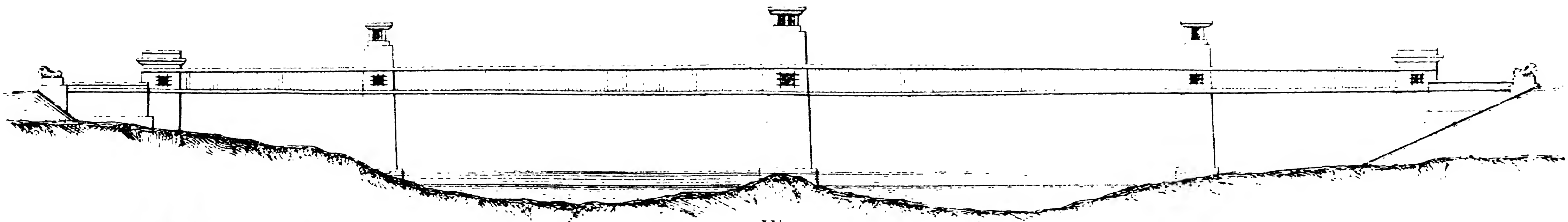


Fig. 4

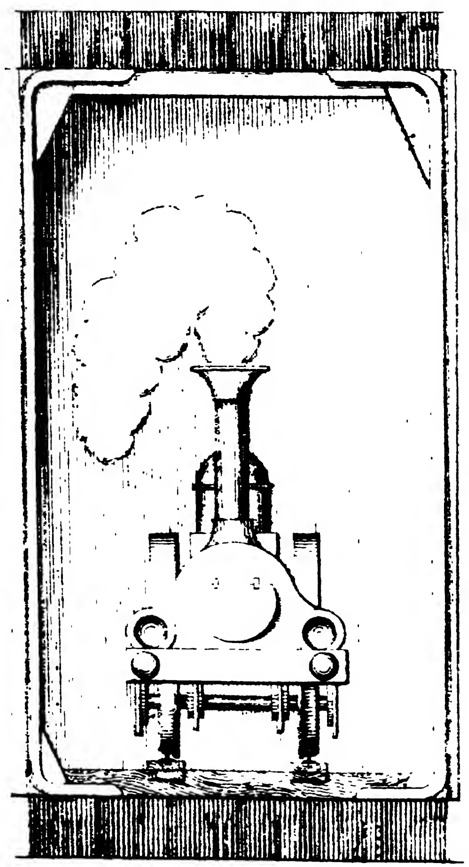


Fig 5

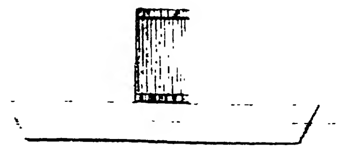


Fig 7

Fig 3.

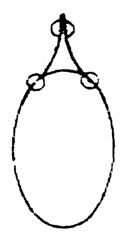


Fig. 1.

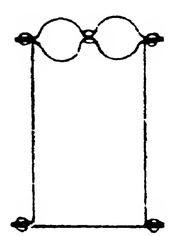


Fig 2

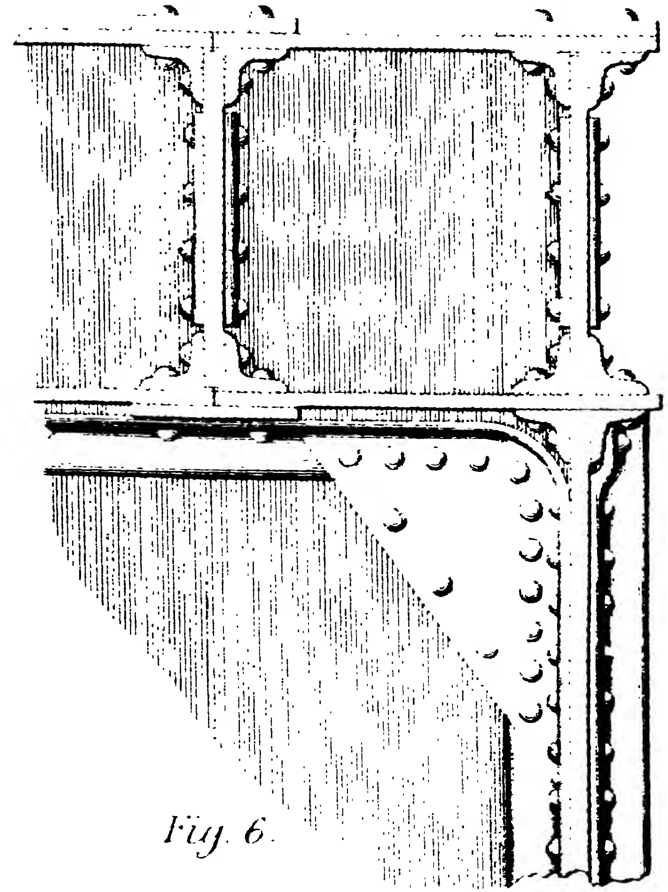


Fig. 6.

masonry and brickwork, and 479 tons of iron built in. The side towers are almost as large, rising 177½ feet from the plinth. The abutments each 176 feet in length are 87½ feet in height on the Carnarvon side, and 143 on the Anglesea side. They are terminated by projecting pedestals, on which are placed colossal couchant lions, weighing 30 tons. The entire amount of masonry in the bridge is one million and a half of cubic feet or 100,000 tons, which it is calculated was built up continuously for twelve hours a day, at the rate of three cubic feet per minute.

The two tubes are now continuous over all the spans, the greatest depth being thirty feet in the Britannia tower, tapering down in a parabolic curve to twenty-three feet at the ends. The large sections for the spans of 460 feet have eight cells at the top and six at the bottom, as shown in section, Plate XXIII, fig. 5. The general dimensions are as follows:—

	Weight. Tons.	Sectional area in centre. Square inches.
Top	1481	648·25
Sides	1727	302·00
Bottom	1472	585·43

The two tubes in their present state, 1511 feet in length, contain, 9360 tons of wrought iron, 1015 of cast iron, and 165 tons of permanent way. They are estimated to have been constructed of 186,000 separate plates and bars united by upwards of two millions of rivets.

In so great a length of iron the effects of change of temperature on the length of the tube is very considerable. In fact, taking the extreme variation of temperature in our climate to be — 5° and + 115° Fahr., or to range over 120°, the variation of the length of the tube would amount to fifteen inches.

To provide for this the tubes are firmly fixed on immoveable bed-plates within the Britannia tower, whilst above they are also attached to suspension-bars firmly connected with the masonry. But in the side towers and abutments they are free to move longitudinally on an arrangement of cast-iron rollers. Above there are suspension rods, which are attached to girders, also rolling freely on gun-metal balls. With these arrangements the tube is in unceasing motion, the diurnal variation of length amounting to from half an inch to three inches.

Another curious effect is that resulting from the unequal heating of the sides of the tubes. They become convex towards the sun from the elongation of the warmer side. Hence, as the sun moves across the zenith they revolve in a plane at right angles to their length in an irregular curve which varies with the weather, and shows the effect of the slightest irregularities of temperature—from passing clouds, for example.

To break one of the girders of the Britannia Bridge would require about 5200 tons distributed uniformly over the 460 feet span, including the weight of the tube. The weight of the tube is 1550 tons, and the weight of a train of the most heavily laden trucks, extending over the entire span, would be about 570 tons. If we deduct the weight of the bridge from the breaking weight we have a surplus strength of 3650 tons to resist the rolling loads, or the proportion of six and a half to one, nearly. Or according to another method of calculating the strength, for the authorities differ at present as to the proper plan, $1550 + 570 = 2120$ tons, which must be considered as the maximum load which can be brought on the bridge. The strength will then be nearly two and a half times the maximum load.* The deflection of one of the Conway girders from its own weight was nine inches in the middle; that of the larger Britannia girders twelve inches.

IV. *The Construction of the Tubes.*—The tubes for the Conway Bridge were constructed on a platform on the beach of the river, 420 feet long by 40 wide, workshops containing shearing, punching, and riveting machines, with furnaces and forges, being erected on the land close by. The plates as they were wanted were straightened by a hideously noisy process of hammering on massive cast-iron bed-plates, or by the quieter process of passing through rolls. They were then sheared to the exact size, and the positions of the rivet holes marked ready for punching. The ordinary punching machines have one, two, or three punches which rise and descend with a slow reciprocating motion of about four strokes a minute, and they have dies of the same size beneath. The workman adjusts the plate with great dexterity between the punch and die, so that at each descent of the former a hole is made in the required position. This is effected with the greatest ease, although forty tons pressure is necessary to punch a hole of ordinary size in a three-quarter inch plate. A very remarkable self-acting punching machine, by Mr. Roberts, was partially employed for the Britannia Bridge. It worked on the principle of the Jacquard loom, and punched any pattern of holes across the whole width of the plate without previous marking, the plate being carried forward on a sliding table. The importance of the operation may be judged from the fact that, according to Mr. Clark's calculations, there are seven millions of holes in the Britannia Bridge alone. The plate when punched was removed to the erecting platform, and carried by means of a travelling crane, moveable, over the whole extent of the stage, to the position it was to occupy in the girder.

* The effect of the continuity of the girders in strengthening the bridge has, however, been neglected in these calculations.

The annexed figures illustrate the nature of the riveted joints of the bridges. Fig. 1 is a rivet with one head formed ready for use. This is put through two corresponding holes in the plates to be united, and a second head formed by hammering. A section of such a joint is shown in fig. 2.

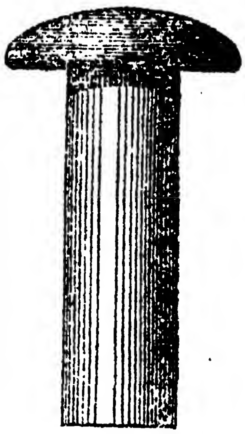


Fig. 1.

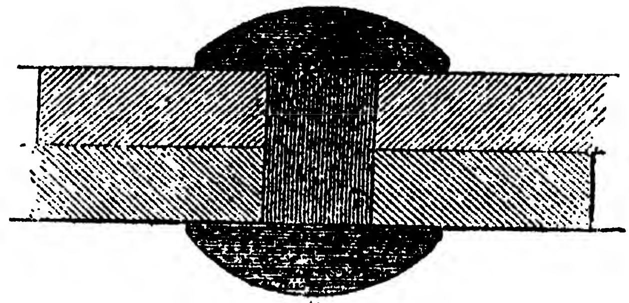


Fig. 2.

In the Britannia Bridge the four land-tubes were erected in their permanent position on scaffolding of great strength. The four larger tubes, each 472 feet long, were built on the Carnarvon shore of the straits, on similar stages to those employed at Conway; workshops adjoined to them on the land, and behind these were cottages for 500 workmen.

V. *Floating and Elevation of the Tubes.*—We have seen that the original intention of throwing suspension chains across the straits to form a platform on which to erect the girders was abandoned. A simpler, less expensive, and more efficient plan was devised, that, namely, of building them on the shore, where pontoons could be brought beneath them at low water, so as to float them with the rising of the tide; thence to guide them safely about 500 yards as they were impelled by the current, and to drop them, as the tide again fell, on masonry shelves at the bottom of the towers. A description of the manner in which this was effected for one of the main Britannia girders will suffice for all. The preliminary arrangements comprised the attachment of two huge twelve-inch hempen cables near the tube, and extending them across the straits to capstans on the Anglesea shore. These guide-cables passed through hawse-holes in the outermost pontoons, and guided the ends of the tube. Immensely powerful friction-breaks were placed in the pontoons on each of these guide-cables, by which the motion of the tube could be retarded in any required degree, as it was feared that, left to the current, it would become unmanageable. To haul the tube out of its position in-shore two eight-inch cables were extended across the straits from moorings on the Anglesea shore to capstans on the pontoons. Lastly, four other capstans were placed

along the shores with cables moored out into the stream; these were taken up in turn as the tube reached them and served for adjusting it to its resting-place in the towers. Thus prepared, with the aid of Captain Claxton and a large body of sailors, the operation of removal was commenced. An ineffectual attempt was made with the first tube on the evening of June 19, 1849. Next evening Mr. Stephenson, with Mr. Brunel, Mr. Locke, Captain Claxton, and some friends again took their places on the tube, watched by thousands of anxious spectators from every accessible point along the banks. Slowly as the tide rose the pontoons took the tube from its bearings, the land attachments were cut, and the tube swung majestically out into the stream, held by a radius chain extended up the shore. This was cut, and the tube slid slowly down the great guide cables, Mr. Locke and Mr. Brunel assiduously watching the application of the friction breaks, whilst from the top Mr. Stephenson signalled by flags to the various capstans on shore. As the buoyed ends of the other cables were reached they were attached; the tube was brought up against a butt near the Anglesea tower, and on this, as a fulcrum, swung round to its position at the Britannia tower. It was hauled home here, and the other end glided into its place. Gradually, as the tide fell, the pontoons left their stupendous cargo safely resting on the bases of the towers.

The tubes weighing 1,550 tons had now to be raised to a height of 100 feet. This was effected by three enormous Bramah presses,* placed at the top of the towers and worked by steam-engines. Massive flat-linked chains were suspended from the cross-heads of the presses in the towers, and attached to the ends of the tubes; each link six feet long had a square shoulder by which it was attached to the cross-head by clips. As the

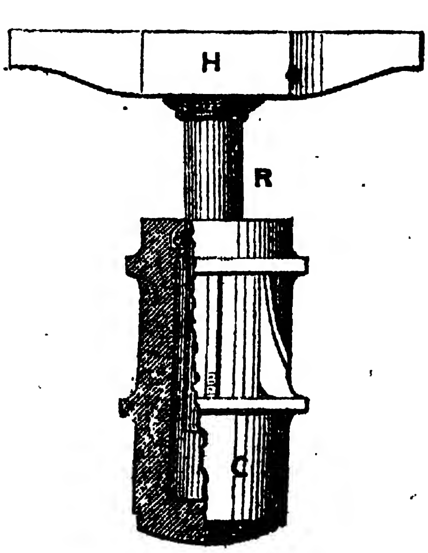


Fig. 3.

* The hydraulic press improved and introduced into general use by Bramah acts upon a principle long understood, the application of which in the production of great pressure was suggested by Pascal in the middle of the seventeenth century. It consists of a cylinder, C, into which water is pumped at a considerable pressure, either by hand, or, as in the case of the bridges, by steam-engines. In the cylinder is a solid ram, R, sliding freely through a peculiar water-tight joint at the top, the invention of which is due to Bramah. H is the crosshead from which the chains were suspended. The water is pumped in through a small pipe (not shown) at a pressure of about three

water was pumped in, the ram rose through its stroke of six feet, lifting the tube to that extent. The chain was then gripped by a second series of clips on the massive beams beneath the press; the ram was finally allowed to fall, and having grasped the chain six feet lower, began a new stroke. The tower was built up beneath the tube as the raising was effected. Thus, by slow stages, between the middle of August and October, the first tube was raised to its place. Delay having been caused by the failure of one of the presses, an accident which threatened the destruction of the tube. The other tubes followed. The last was floated July 25, 1850;—the first stone of the bridge having been laid September 21, 1846. Thus ends our brief account of the design, construction, and erection of these bridges, and although we can hardly hope that all the technical details of the subject have been clearly explained to our readers, yet we trust that we have imparted to even the most popular inquirer some idea of the great difficulties which have been overcome, and of the wonderful work which has been achieved in the completion of a magnificent work of engineering skill, which is the pride of every Englishman, and elicits the admiration of every foreigner who visits our shores.

tons per square inch. The area of the ram in one of the Britannia presses was 270 square inches, and the lifting power about $270 \times 3 = 810$ tons.

In order to pump in the water two forty-horse power steam-engines were employed, working pumps $\frac{1}{10}$ inch diameter. The area of each pump piston was, therefore, 0·886 square inch, and the pressure against this at three tons per square inch 2·6 tons; it was against this resistance only that the power of the engine was exerted in producing a lifting pressure in the press of 800 tons.

Fig. 3 represents an hydraulic press, partly in section, partly in elevation.

EXPLANATION OF PLATE XXIII.

Fig. 1. The elliptical tube with a fin, or first cellular experimental tube.

2. Rectangular experimental tube, with two cells at the top, familiarly known as the "spectacle tube."
3. Side view of fractured part of one of the experimental tubes, to show the nature of "buckling," or yielding to compression.
4. Elevation of Britannia Bridge. Scale about 1-3210th.
5. Cross section through the middle of one of the Britannia tubes, showing cells, &c. Scale about 1-124th.
6. Upper corner of fig. 5, on a larger scale, showing arrangement of plates, angle iron, and covering strips, to form the cells, &c. Scale about 1-15th.
7. End view of one of the tubes resting on the pontoons.

PRIMITIVE ASTRONOMY.

BY THE EDITOR.

"THIS is a fine, clear night, sir; is it not?"

"Indeed it is: and how brightly that star shines above all the rest."

"It does; pray what star may that be, sir?"

"Why, it is called Jupiter: correctly speaking, it is not a star; but I dare say you know as well as I do that it is a world like the one on which we live."

"A world, sir! No! *Then have navigators really got as far as that?*"

This is no imaginary dialogue; the speakers were a Liverpool cab-driver and the writer of these lines.

Three or four hours' confinement in a crowded saloon had induced us to seek the cool evening air, on our return home from a place of public entertainment; and leaving our companions to occupy the inside of the vehicle, we selected the less dignified but more airy seat beside the driver, and were accordingly favoured with an excellent opportunity, had we been so disposed, to deliver a popular lecture on astronomy to a limited, but attentive and inquiring auditory!

The refreshing breeze from the Atlantic, and the cloudless, starlight night, had not, however, operated in this direction; they had so raised our spirits, that when the last exclamation escaped from our companion, our first impulse was to laugh outright at the absurdity; but an instant's reflection showed us that such a state of ignorance, even in an uneducated cab-driver, should rather move to pity than to merriment; and we endeavoured, as well as we were able, to make our companion understand, that it is impossible for human beings to breathe and live beyond the limits of our atmosphere, and that our knowledge of the nature and position of the star which shone so brightly in the heavens, was the result of reasoning, aided by the employment of philosophical instruments.

But what a deplorable illustration did this man present of the ignorance still existing in this our boasted land and day of enlightenment, when "Working Men's Institutes" are the

fashion, and the lord lectures to the labourer! Here was a citizen of the most important seaport in the world; one who in all probability had an indirect voice in the government of the country; who may have attended divine worship regularly, and have formed some idea of the nature of the Godhead; ay, for all we know, he may have been and may still be a zealous member of some "Cabmen's Missionary Society," actively employed in the task of converting sinners; and yet this man was almost as ignorant of the true character of the natural world by which he is surrounded as the poor dumb brute that he lashed with the whip or encouraged to proceed with a clack of his tongue.

Why, if those Chaldean shepherds of old, who are said to have been the Fathers of astronomy, and whose occupations are to some degree analogous to those of our cab-driver; if these had possessed half his advantages, had been acquainted with the use of electric telegraphs and railways, and been able to learn all that was known in their day through the medium of the printing press, for the cost of a draught of their wine, they would have far exceeded this man in intelligence! And yet it is thousands of years since these poor shepherds watched the sun in his annual and diurnal course, marked his progress in the heavens, and, with him for a teacher, learnt how to divide the year into its due times and seasons. And the ignorance of the old astronomers, even those of Heathendom, was edifying beside that of the uncultivated minds which cast such a shade over the brightening intelligence of our Christian era. *Their* erroneous notions were at least poetical, and bore the mark of some kind of religion, whilst in our day this absence, in an adult, of the veriest rudiments of education is only suggestive of debased habits, and physical as well as moral depravity and destitution.

Take, for example, the primitive theories concerning the Sun's nature.

The ancients were not content to receive his warmth and light; caring nothing as to whence he came, or whither he went, as do the ignorant of to-day, to whom life is but a season of sensual enjoyment.

No, they strewed his path in the heavens with the flowers of poesy and sentiment.

Even whilst the earth was still regarded as a flattened plain, bounded on all sides by the ocean, the heavenly bodies were believed to emerge from the latter at their rising, and again to sink into its depths at their setting.* The Iberians believed that they heard the hissing of the water when the burning Sun plunged into the Western Ocean.

* Lewis. "Astronomy of the Ancients." 6, *et seq.*

"The Greeks even conceived the Sun in the personified form of a divine charioteer who drove his fiery steeds over the steep heaven until he bathed them at evening in the western wave."

Nor were these observations, which at first served only to impart some reality to the Mythology of the Ancients, useless in their subsequent results.

The question naturally arose: If the Sun emerged from the Eastern side of the world, and descended under the Western horizon, where was it during the hours of darkness?

Gradually the researches of one astronomer, and of one school of astronomers after another, led to the conclusion that it passed *underneath* the Earth, and revolved round it along with all the other heavenly bodies. The Earth was, therefore, constituted the centre of the Universe. This step in astronomical knowledge being accomplished, other discoveries succeeded. The rotundity of the Earth, the unequal motion of the Sun, the Earth's motion, the central position of the Sun, and the nature of the planets and fixed stars, were all revealed one by one, until the harmonious moving Solar system assumed the place of the flat, immovable Earth with its crystal vault of Heaven wherein were set, like so many sparkling jewels, those myriads of stars to which "navigators" could not penetrate.

Let us endeavour, in the few pages at our disposal, to trace the first efforts by which the human mind was emancipated from the thraldom of ignorance, and which subsequently led to the acquisition of a knowledge of the actual nature of the Solar system, and of so much of the universe as has been revealed by the telescope.

It is hardly necessary to explain why the ancients believed the Earth to be a flat plain. With the exception of its hills and valleys it appeared so to the naked eye, and its inhabitants had neither instruments wherewith to observe their receding or approaching barks on the ocean,* nor were their vessels of such a character as to admit of the complete circumnavigation of the globe. They consequently judged of the Earth's form, for a length of time, by the evidence of their senses only, holding it to be a circular plain surrounded on all sides by water upon which it floated; and the firmament above was regarded as a solid vault, various astronomers attributing to it a different composition.

Some, for example, conceived it to be a "fiery ether;"

* Doubtless most of our readers are well aware that one of the proofs of the Earth's rotundity is found in the fact that the masts of vessels are the last portions which disappear below, and the first of which appear above the visible horizon.

others, that "the extreme part of the heavenly sphere is earthy and solid;" and others, again, imagined that the blue sky consisted of "air condensed by fire so as to assume the substance of ice." This firmament was supposed to revolve around the Earth, and the stars were believed to be attached to it, *their* nature again being the subject of much consideration and discussion. According to some of the Greek astronomers they were "circular bodies of condensed air containing fire," whilst others regarded them as "compressed fire fed by exhalations from the Earth," and others, again, as "stones ignited by the fiery firmament."

The last theory was propounded by Anaxagoras, a Greek philosopher, who probably entertained this idea from the examination of aërolites, of which one of large dimensions fell during his lifetime (about the year 468 B.C.), in Thrace.

His views concerning the heavenly bodies generally were rather more rational than those previously adopted, and in some cases he arrived at conclusions which have been confirmed by the revelations of modern science.

Whilst, for example, one observer compared the Sun to a wheel, of which the spokes were the rays, and another likened it to a "bowl or hollow hemisphere" (a solar eclipse taking place when the luminous convexity is turned upwards and the dark concavity towards the Earth), this bowl being no larger than the Sun really appears to the naked eye, namely, about the width of a man's foot;—whilst, we say, these were the extraordinary notions entertained by some philosophers concerning the orb of day, Anaxagoras had arrived at the conclusion that the sun is a mass of ignited stone, and his ideas of its size were so somewhat advanced, for he believed it to be "larger than the Peloponnese." But what is more remarkable, he believed the Moon to be an "Earth having its plains, mountains, and valleys, and likewise its inhabitants." He considered that it derived its light from the Sun; arrived at correct conclusions as to the cause of eclipses of the Moon, believing them to be due to the interposition of the earth between the Sun and Moon, and on all subjects he wrote with "boldness and freedom."*

The reader will not be much surprised to hear that as a result of this enlightenment he was persecuted by the adherents of the established religion; compelled to move from city to city; was accused of impiety, imprisoned, fined, and that he at length emigrated. He died at the age of seventy, about 430 B.C.

Anaxagoras not only wrote on astronomy, but also on the

* These quotations concerning the astronomical theories of the ancients are from Sir G. C. Lewis's work.

mythology of his people, exposing its fallacies and the allegorical character of the gods. This, no doubt, drew upon him the animosity of the orthodox of that day, more than did his physical discoveries; for we find that in every age the revelations of science have had the simultaneous effect of dispelling the clouds of ignorance and superstition.

But we must retrace our steps and return to the earliest astronomical discoveries.

We find that, at all times in the history of our race, the most important advances in knowledge have been, more or less, directly associated with the physical requirements of the people by whom they were made; and in no phase of human intelligence is this so manifest as in that which relates to the progress of astronomical knowledge.*

Let us for a moment suppose a completely untutored race of human beings placed in some tolerably fertile region of the globe, with purely animal wants and instincts, and with the capacity of adapting themselves to surrounding circumstances. These lowly wants would alone compel them to direct their attention to astronomical occurrences.

At first the natural and spontaneous productions of the soil suffice for their sustenance. Fruits, esculent roots, and the flesh of animals not only afford them nourishment, but even minister to their taste for luxuries. As evening approaches they find themselves weary and lie down to rest, and with each returning morn comes the renewed strength which Providence infuses during sleep, and which prepares for the labours and pleasures of the coming day.

But such a people as we are describing soon discovers that trees do not always bear fruits, that game is not always found in plenty, and that when plants appear to die, the animals which feed on them, and which in their turn serve the human inhabitants as food, retire to their haunts to seek shelter from the inclement season.

The human denizens, however, continue to multiply in winter as in summer, in rain as in sunshine, and a store of food must therefore be laid up for their little ones as well as themselves, or they would perish.

Their earliest observations, prompted by their lowest animal feelings and appetites, cause them to perceive that whenever they are most in need of food and warmth the Sun is low—that then it possesses but little power—whilst, when their trees and shrubs are producing fruit, and food is plentiful, he stands high

* The publication of the "Nautical Almanack" by the first maritime nation in the world, has, perhaps, prompted a more diligent scrutiny of the heavens than any other circumstance in the history of our race.

in the heavens and emits his most powerful rays.* Their first impulse is naturally to regard him as a deity.

And so it was in ancient times; the Sun was worshipped as the giver of light and warmth, and of all the richest fruits of the earth; and his movements in the heavens were closely watched in order to obtain some clue with regard to his true nature.

But in addition to this power of observation which our race possesses, another attribute of reason is that which prompts us to *record* impressions made upon the mind with a view to guide our contemporaries and posterity. This is a characteristic in the mental nature of man which serves as a marked distinction between him and the lower animals, and constitutes the difference between his education and theirs.

The ant and the bee convey information to their congeners of the discovery of a store of provender; the cat can teach its kitten, and has even been known to instruct a young dog in the art of begging† (the most striking example of educability in the lower animals that we have seen recorded); but in these and similar cases the capacity is limited to the individual and never extends to the race. Should all the parent bees or ants die, or be removed before the young ones are born, no record will have been left to them of the experience of their progenitors, and the store or booty must be rediscovered, by accident or instinct, before it can become available for their use.

Not so with man. The traces of his active mind and restless enterprise are everywhere to be encountered: in history, the arts, ancient relics, and works of engineering industry; and the records of many of his earliest impressions still serve us as guides in every-day life. No illustration of this is more striking than the sun-dial, one of the earliest devices of man for regulating his physical and mental operations, and at the same time an index to some of the earliest manifestations of his mental development; and yet this primitive chronometer is still in use, on the walls of village churches, as well as on the lawns of the affluent.

When our ancestors watched the daily progress of the Sun through the sky, they perceived that, as he rose towards the zenith, the shadows which he cast on the ground became shorter, whilst, as he descended towards the horizon, they increased in length; and they also noticed that there were certain periods or seasons when his shortest, or what we term his noon-day

* Some of the ancient nations had only three seasons instead of four as in our day. The most striking changes in nature took place in Spring, Summer, and Winter, and these were the subdivisions of the year. Autumn or Harvest ("Herbst" of the Germans), was a later introduction.

† Jesse. "Popular Science Review," No. I., p. 118.

shadow was longer than it was at other periods. In order to record these phenomena, and the better to trace their cause, they simply set up a pole in the ground, and marked the length of its shadow at regular intervals.*

They soon found that the noon-day shadow increased in length day by day until it attained a certain measurement, and that then it remained unchanged for a few days; after this it as regularly decreased until it arrived at its shortest dimensions, and then again stood still for a while before resuming its diurnal increase.

The period when it was the shortest was called the summer "solstice;" the Sun then "stood still," high in the heavens, and its heat was the greatest. The longest noon-day shadow constituted the winter "solstice," and the duration from either of these phenomena to its recurrence was *a year*.

It was found also that about midway between these periods (the summer and winter solstices) there were two others, when the day and night were equal, and these two periods were known as the equinoxes, all these terms being still employed by astronomers.

In like manner did the ancients measure off the gnomon's shadow from the Sun's rising until his setting, and employ it to denote the time of the day. Thus, we are informed that "a person was invited to dinner by asking him to come when the shadow of the gnomon was so many feet long;" and, as in our day, we have a "Greenwich time" for our clocks, so are our ancestors said to have had a standard measure by which their gnomons were regulated.

The changes referred to, in the relative position of the Sun and Earth, offer no problem to our modern astronomers, who know that these appearances are due to the annual revolution of the Earth round the Sun, and the daily rotation of the former on its own axis.

But to the dawning intellect of the shepherd astronomer the consideration of these phenomena was fraught with many difficulties, for he believed the firmament to be a solid sphere in which the heavenly bodies were firmly set, and with which they, therefore, revolved around the Earth as a centre. How, then, could the Sun deviate from its regular course, now rising and setting in one part of the heavens and now in another, whilst the constellations (for, from the earliest ages, the fixed stars were mapped out in groups) always maintained the same relative position in the firmament, rising and setting

* In common with many astronomical discoveries, the earliest application of the sun-dial (or "gnomon"), is buried in obscurity. It is supposed to have been invented by the Babylonians.

one day as another, and showing no perceptible change in their movements.

Nor was his perplexity diminished when he found that what applied to the Sun was still more strikingly manifested in the movements of the Moon, for not alone did her course in the heavens vary from day to day, but with it her very appearance became changed.

Sometimes he found her highest daily altitude to be less than that of the Sun in the depth of winter, whilst at others it was even greater than that of the same luminary at midsummer. Again, at one time, the Moon appeared to be advancing towards the Sun in the heavens, and at another to be receding from the position which he occupied; whilst, strange to say, the nearer she approached him the less luminous she became, assuming at length the form of a thin bright crescent, whilst, with increased distance, came greater brilliancy; and, as she receded from the Sun, the crescent gradually expanded into a broad circular luminous disc, which almost sufficed to convert night into day.

But another and a still more surprising phenomenon was soon revealed to the wondering gaze of the early student of the heavens. Even the stars themselves did not appear in every case to be fixed in the celestial vault, and one bright wanderer* after another seemed to start from his fixed home in the heavens and slowly to mimic the movements of the great luminaries of day and night, until no less than five had been discovered who refused to be held by the inflexible bond that fettered all the rest.

Judging from their degrees of brilliancy and the comparative changes of position to which they are subject, modern astronomers are disposed to believe that first Venus, next Jupiter, then, consecutively, Mars, Saturn, and Mercury attracted the attention of the star-gazers of ancient days; and it was soon discovered that two of these planets—Mercury and Venus—were nearer to the Sun than is our Earth, and that they actually passed behind it and revolved round that luminary.†

How great must have been the perplexity of our ancestors as, one by one, these abnormal and apparently contradictory phenomena forced themselves upon their observation! How troubled they must have been to account for these apparent changes in the regular order of nature as conceived by their predecessors and themselves!

The Sun, indeed, revolved round the Earth at regular inter-

* Hence called "Planets," from a Greek word signifying to wander.

† The ancient Egyptians were well aware of this fact. See "Chambers's Handbook of Astronomy," diagram on p. 25.

vals, as did also the Moon, the planets, and the stars; but, then, how could they be fixed in one revolving dome, when the orbits of the two former were elevated or depressed at various seasons and periods of the year? the Sun requiring a year, and the Moon about twenty-nine days to complete its cycle; five of the stars wandering without any apparent order, but all the rest fixed and immovable, as if to silence the doubts of the heterodox, and to confound the calculations of ingenious speculators. But to give a final blow to the theory of the Earth's central position and the one revolving firmament, it was discovered, after a lapse of many centuries of careful observation, that the Sun's path in the sky was gradually changing, to speak familiarly; that it did not rise and set with the same stars at the same period every year, but was gradually moving towards the west, leaving the fixed stars behind it.*

Many and ingenious were the theories by which the apparently eccentric motions of the heavenly bodies were sought to be explained. The circumstances to which we have referred, and the discovery of the true nature of eclipses, rendered the theory of one single solid firmament equi-distant in every part from the central Earth around which it revolved, quite untenable; and the first important step in ancient cosmogony was that which divided the crystalline vault of heaven into belts or zones more or less distant from the Earth; each belt containing its own section of the heavenly host.

The Moon was known to be nearer to the Earth than the Sun, for her dark body was found to interpose between these two spheres, and she therefore was placed in the nearest zone: next came the zones of the Sun, planets, and fixed stars respectively, each making its own appropriate revolution.

This theory met one difficulty, namely, the variable distances of the different heavenly bodies from the Earth, and even to some extent, the regular elevation and depression of their orbits; but it was not sufficient to account for the slow changes which took place in the latter, and to explain this phenomenon, Pythagoras† supposed a motion in the Earth itself, and removed it from its central position in the Universe. His cosmical system was, however, very vague, and was made up of a strange compound of fiction and fact. Such as it was, however, it maintained its position until the true nature of the Solar system was revealed 2,000 years subsequently by Copernicus, the great Polish astronomer.

We shall now present to our readers the Pythagorean system, as enunciated by his followers, in contrast with the earliest

* The precession of the Equinoxes. See any Handbook of Astronomy.

† About 500 years B.C.

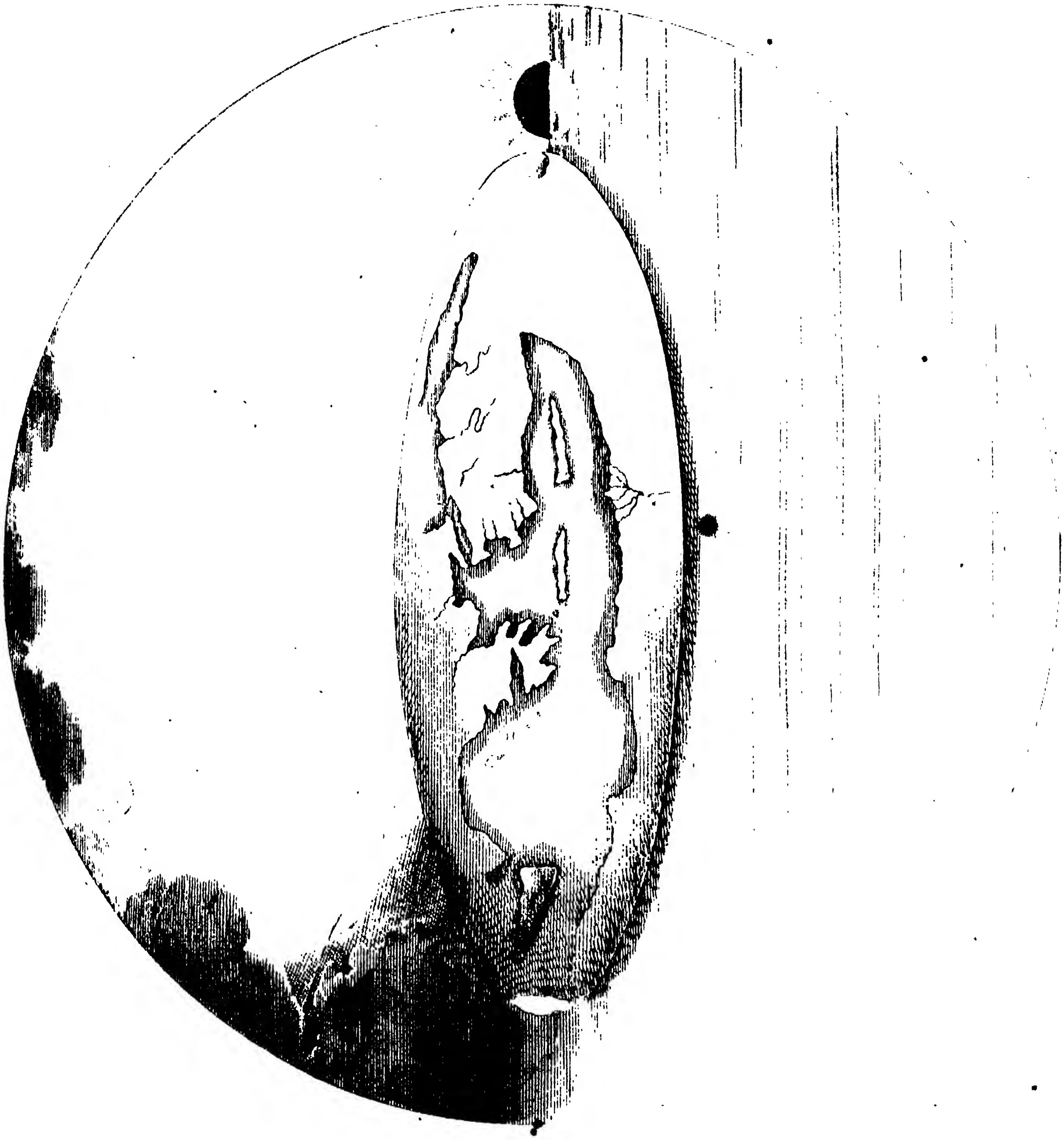
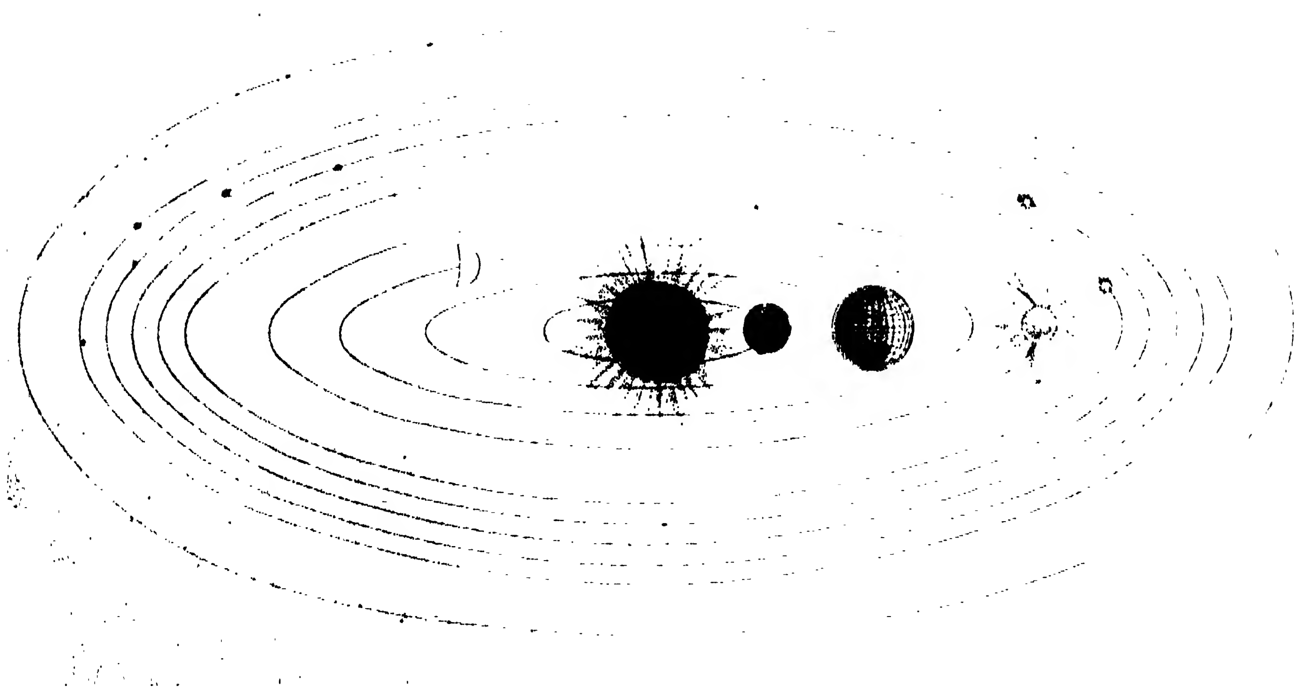


Fig. II



received ideas on the same subject, and shall then be compelled to draw these observations to a close.

For this purpose we would direct the attention of our readers to the accompanying plate, in which the first figure represents the Universe, as it was believed to be constituted in the time of Homer; and the second (which is based upon the exposition of the Philolaic system, published by Professor Aug. Bœckh, of Heidelberg, in 1810) is an ideal view of the same, according to Pythagoras and his school.

In the first figure we have the world, according to Homer, a flat circular body, floating upon the ocean by which it is surrounded. In the east is the sun, rising from his "Lake,"* to pursue his daily round, and tinting the plains of western Palestine with the rosy hue of morning.

In the west, darkness still reigns over the land. The Moon and stars, firmly set in the crystal dome of Heaven, cast their silvery light upon the Adriatic Sea, and on the island of Thrinacria (Sicily), whilst still farther west is the fabled land "Elysium," the region of eternal light, and the dwelling-place of the blessed; and beyond that, the stream of ocean which had to be crossed by disembodied spirits before descending into Hades, which was supposed to be situated beneath the Earth.

The second illustration which, as it will be seen, is more in conformity with the true theory of the Solar system, represents the views of Pythagoras and his school, and is generally called the Philolaic system, from its enunciator Philolaus, who lived and taught in the fourth century before Christ.

According to this school of astronomers the heavenly bodies were spherical.

In the centre of the Universe was the "Central fire," *not* identical with the Sun, but probably imparting to him his warmth-infusing rays. Next came the "Antichthon," the nature and functions of which are not clearly defined, but which is supposed by a modern writer † to have been a body that represented what in reality was the side of the Earth unknown to the ancients.

Then followed the Earth deriving its light and heat from the Sun, which was supposed to be external to it in the universe; after that came the Moon, next the five planets, and lastly the fixed stars. (See Plate XXIV.)

The Antichthon, Earth, and all the heavenly bodies revolved round the Central fire. The former was not visible from the Earth at any time, revolving with it, but sometimes interposing between it and the Moon, which it then eclipsed! ‡

* Smith's "Ancient Geography." † Sir G. C. Lewis.

‡ The Antichthon evidently performed the functions of the Earth's shadow.

The zone of the fixed stars was the true Heaven or Æther in which the gods dwelt, and from whence they descended from time to time to favour the sons and daughters of Earth with their celestial society.

It would be impossible for us here to refer to all the teachings of the Pythagorean school. Their doctrines explained every celestial phenomenon, real or imaginary; the supposed distances of the heavenly bodies from the Earth; their motions; the eclipses; the milky-way, and *the music of the spheres*, which was supposed to exist although it was inaudible.

And wherefore, does the reader suppose, it was "inaudible?" According to some philosophers, it was in consequence of the "constant habit" of hearing it; whilst others attributed the silence of this harmony to its "extreme loudness!"

However, imperfect as these teachings were, they held their sway until, in the sixteenth century, Copernicus laid the foundation of that theory of the universe which places the Sun in the centre of our system, and converted the fixed stars into so many solar centres of other systems, at present immeasurably distant, but which the magic tube and the advancing intelligence of man are bringing nearer to us day by day. With these distant worlds mankind will no doubt one day be better acquainted than we are at present with the nature of those companion planets that accompany our bright and beautiful world in its annual revolution round the central orb of light.

"But why," some of our readers may be disposed to inquire, "in a periodical devoted to the popular exposition of scientific truth, are we treated to a dissertation upon the errors or crude conceptions of our forefathers, long since defunct and forgotten?"

"Why," we would ask, in reply, "is it pleasant to unbend, after the rigid and wearisome study of those subjects which tax our powers to the utmost, and to listen to the innocent prattle of our children as they discourse learnedly upon these all-important topics, and endeavour in their innocence to cut through those knotty problems which we are seeking laboriously to unloose?"

It is as agreeable to the modern student of science to look back upon the half-mythical theories; upon the imaginings of the earliest inhabitants of our globe, as it must have been to the parent who had taught his child that it was God who made the stars, to hear his little one exclaim, as the first twinkling light made its appearance in the heavens, "See! see! God has made a star!"

But there is also an important lesson to be derived from the consideration of this interesting subject, which recommends

itself especially to the attention of the student of nature, namely, that the operations of the great laws which rule the physical world may also be traced in the realm of mind.

There is a rule, well known to naturalists, in the development of the animal races, and one to which we have frequently had occasion to refer elsewhere, that those creatures which hold a higher place in the scale of life, have to pass during their life-time through the various stages which characterise the humbler forms in *their perfect* stage. Many examples might be adduced from the history of the animal tribes to illustrate this fact; but it is only necessary to refer to one, which we shall thus state familiarly. Man, in the course of his physical development from the germ to the mature being, passes through the various forms assumed by the lower vertebrates in their perfect state.

Now, the same law will be found to exist in the *mental* development of the individual, as well as in that of the whole human race. Each intellect, before it can become fully expanded, must pass through the stages of utter ignorance and semi-enlightenment, whilst the records of history show that the human race also has had an infant mind, and is passing through progressive stages of intelligence.

The ancient Greeks and Hebrews, who conceived that the stars were set in the vault of Heaven, may be ranged side by side with the child who says that God has made a star; believing that He has just set up a twinkling light in the heavens.

The more advanced Pythagorean, seeking to break through the cloud of ignorance which obscured the intellect of his age, and groping his way darkly towards the truth, resembles the youth who passes through the probation of his school-days; whilst the modern astronomer, who is still younger in knowledge compared with those who will succeed him, may be likened to the young man immersed in his collegiate studies: upon whom the principles of truth have dawned, and who will employ the remainder of his life in their practical application!

This is no fanciful picture; no vain and imaginary simile! It is but another illustration of the unity and simplicity of that law which regulates the affairs of the universe; alike bringing the humblest protophyte into existence, and developing the noblest of all living creatures—man! And it is the enunciation of the awful yet beneficent will of that one great Creator and Ruler, who has made, and who sustains and governs all things, visible and invisible—in the world of time as in that of eternity!

THE PHYSICS OF A SUNBEAM.

BY ROBERT HUNT, F.R.S.

TO reduce our inquiry into the most simple form, it appears necessary that the reader should be invited to accompany the writer into the dark room employed in his illustration of "Light and Colour;"—a room, indeed, so dark that even after the eye has accustomed itself to the absence of any illuminating power, it shall not be enabled to distinguish either the forms or colours of surrounding objects. Under such conditions the eye is a useless organ; the sense of sight is not excited, we have lost the power of distinguishing bodies, which we cannot touch. Some agent external to ourselves is required to complete the connection between us and distant objects—to excite, indeed, the sense of sight.

Let us perforate with a steel point the window-shutter; a sunbeam enters and falls on the floor, forming a disc of bright LIGHT. From this circle radiation takes place; and, although it may be faintly, still the reposed eye begins to *see*. The radiations have diffused themselves, they have fallen on the surfaces of the articles around us, and then again the weak rays have been radiated to the eye. The myriad delicate nervous fingers, which spread over the retina, are touched and they tremble at the touch. The varying sensations are conveyed to the brain and the phenomenon of vision is established.

If the hand be placed in the path of the sunbeam the sensation of warmth is communicated; we feel there is HEAT in the ray; or, if a thermometer is so placed that the beam falls upon its bulb, the mercury will expand and rise in the tube. Thus we have the evidence of two distinct classes of phenomena; a third awaits our investigation.

It is well known that photographic pictures are produced by a peculiar chemical change effected upon some salt of silver by the agency of the solar rays. If a piece of paper be covered with the chloride of silver,—which is purely white,—and if this be placed so that our luminous pencil falls upon it, the chemical surface will be rapidly darkened over the space covered by the sunbeam. The change which has taken place, and which is indicated by the alteration of colour, merits some attention.

Chloride of silver—the salt which we have supposed was the chemical compound employed—is one of the most stable character. So great is the affinity of chlorine for silver, that it will combine with, and separate that metal from, almost all its combinations. Yet the moment it is exposed to sunshine it is decomposed; chlorine is liberated and metallic silver is left behind. Such is the remarkable phenomenon; thus teaching us that we have to deal with agencies in the solar rays which are in their visible effects very dissimilar. It became necessary, when the investigations of science were directed to these peculiarities of solar chemistry, to distinguish by a name the agent which was at work. Actinism, a term signifying ray-power, was proposed, and it has been generally adopted to express the chemical principle of the sunbeam. The relations of LIGHT, *the luminous power of the sun; of* HEAT, *the calorific power, and of* ACTINISM, *the chemical power,* will now become the subject of consideration.

The plate accompanying this paper shows three spectral images; which, as they will serve to guide the reader in understanding the somewhat involved phenomena, should be carefully examined as we proceed.

The solar spectrum, which in its chromatic relations has been described in a former paper, must now be considered in connection with its illuminating power. The ray which has the highest illuminating power is the yellow. In either direction the light declines from this point. At the least refrangible end illumination ceases with the extreme red ray, and at the most refracted end there is no ordinary light beyond the violet; or, speaking with philosophical exactness, beyond the lavender ray, which terminates the violet, fading off gradually and beautifully into darkness: there is no illuminating power. Now the maximum of Light and of Heat are not coincident. Sir William Herschel and Sir Henry Englefield long since determined that the maximum of Heat was to to be found in the least refrangible rays. Sir John Herschel has a beautiful experiment by which this is proved, and some new truths added to our knowledge. A piece of silver paper is carefully stretched upon a frame, and being held above a very smoky candle or lamp it is blackened over on one side. After having been thus prepared this screen is placed so that the solar spectrum can be received upon the *unblackened* side. When a very perfect image has been obtained by an accurate adjustment of the prism, and the rays are seen in all their beauty of colour, well defined; the paper is thoroughly saturated with ether, which should be applied with a wide flat brush. The tissue-paper being wetted appears perfectly black, but, in a very short time, the heat-rays drying up this volatile fluid, a curious image is produced which is a picture indeed of the dis-

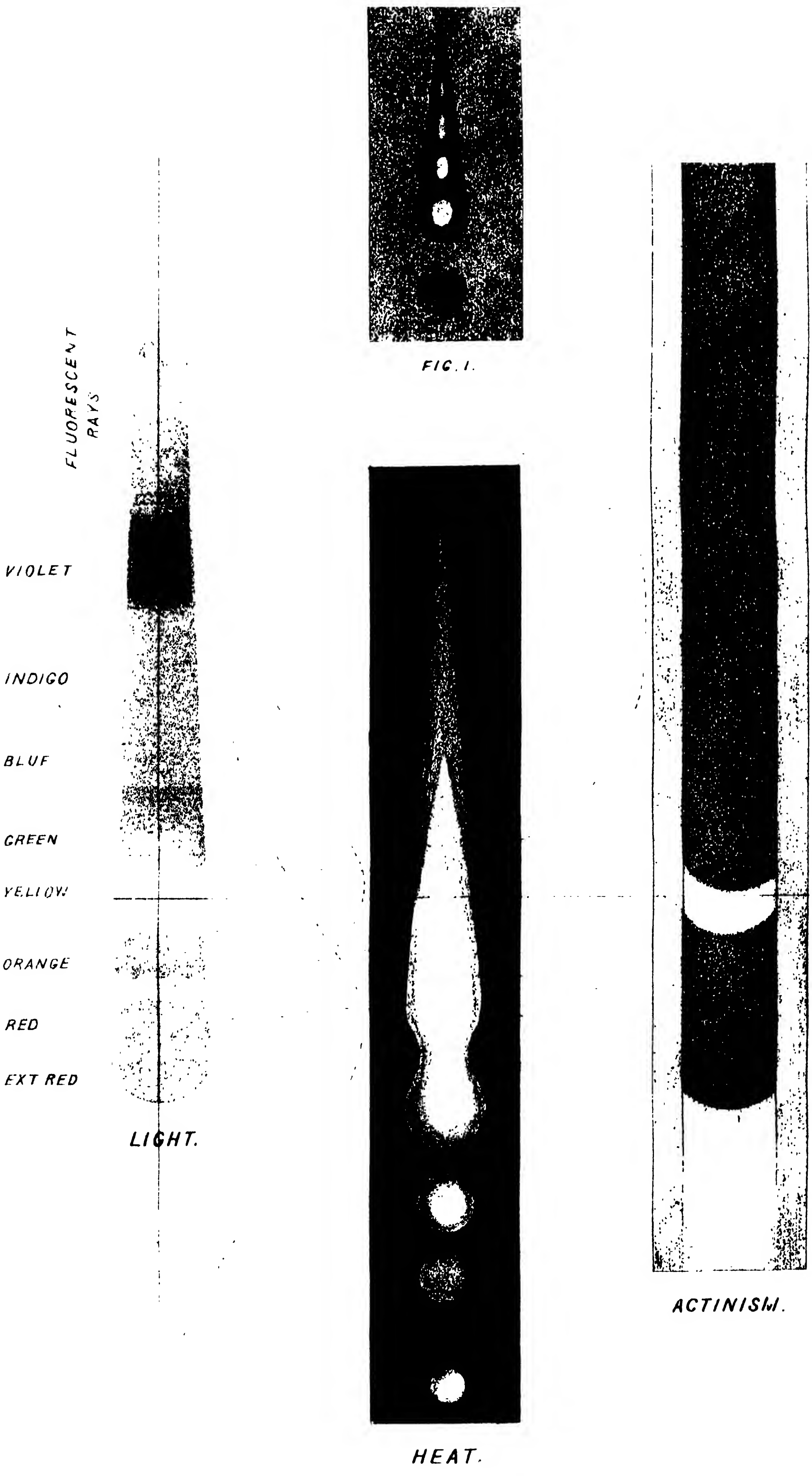
tribution of Heat amidst and beyond the coloured rays of the spectrum (see HEAT in the plate). The first spot dries over a space which is just below the extreme red ray, thus indicating this as the point of maximum calorific power. With gradually diminishing intensity, this drying goes on through the spectrum, presenting on the paper an image similar to that represented in the central figure of the drawing, all indication of Heat ceasing in the violet ray. While this result is being obtained over the space covered with coloured bands of light, three well-defined spots dry out below the red rays where there is no light. These are brought out with greater intensity if a second wash of ether be applied. The heat spectrum is thus shown to be of much greater length than the light spectrum.

Sir John Herschel discovered in these extra spectral heat-rays some peculiar properties; they appeared to possess all the ordinary properties of dark heat-rays, with some peculiar chemical power superadded; hence, to distinguish these from the ordinary heat-rays, it was proposed that they should be called the *parathermic rays*.

These heat-rays have been investigated by Mrs. Mary Somerville, and that lady has added some remarkable facts to the records of science. If the juices of flowers be expressed, and papers stained with them be placed under the action of those rays, many very curious results are obtained. Our space will admit of our describing one only, and that one is represented on our drawing marked fig. 1. In this particular experiment the coloured juice of the dark-purple dahlia was washed over pure white bibulous paper. This being exposed to the spectrum, was gradually changed, over the space occupied, by the parathermic rays, and a brown flame-shaped image was the result, with a spot of a dull red a little below it. By continuing the action, a peculiar internal action was seen to take place, and eventually four spots were formed over the brown space, two of these being red and two blue. It would thus appear that we had, by the action of these peculiar heat-rays, eliminated the two colours, which form, when combined, the purple of the dahlia.

It might be noted, that if chlorophyl, the green colouring matter of leaves, be taken and treated in this way, it is always turned brown by the parathermic rays. It is yet more curious that, at whatever period of the year we obtain this green colouring matter, the resulting brown is always that which marks the autumnal foliage of the plant from which the leaves have been gathered. Investigation continued over many years, shows that the quantity of these peculiar heat-rays varies with the seasons, and that they are most abundant in the sun's rays in the autumn. We may therefore infer that the ripening of fruits and grain, and the autumn tinting of the forest trees, are

THE SOLAR SPECTRA.



THE CURVED LINES SHEW THE POINTS OF MAXIMUM EFFECT.

due to those peculiar thermic rays which are entirely independent of Light though associated with that principle.

The scorching of the sun-beams, which is often observable in the summer and autumnal days, and which is not unusually associated with the appearance of blight on the leaves of plants, has been traced to an excess of these dark heat-rays.

If the spectral image by which the Light and Heat spectrum has been produced be maintained, and we substitute a paper or a glass tablet covered with any of the Photographic preparations, we obtain a spectrum such as is represented on our drawing and marked ACTINISM.

The Chemical tablet is blackened over some parts, and preserved unchanged over other parts. Upon that space which is under the influence of the most Light—as indicated by the line across the page—there is no indication of any change, however long the salt of silver may be exposed to solar action. The space covered by the Heat rays of maximum intensity is in like manner preserved unchanged. Over the region of the red rays some chemical change goes slowly on, and frequently a red colour is produced; in some cases, as when the bromide of silver is used, rising to a fine crimson. The yellow rays have no chemical power, but beyond them the decomposing agency is exerted with increasing force; it arrives at its maximum in the blue and indigo rays, and although it is weakened in force beyond these, the chemical power is exerted to a considerable distance beyond the visible spectrum, where there is no Light.

The results which have been described naturally open the question of the identity of Light, Heat, and Actinism, or the contrary. We have seen that the maximum points differ, and that where light and heat are the most energetic, there the chemical power is the least so.

According to the undulatory hypothesis these differences are explainable upon the supposition that one set of undulations will produce the sensation of Light, that another set establishes the sensation of Heat, and that a different rate of vibration again is the cause of Actinic phenomena.

There is some other evidence which it is necessary to bring before the reader. By means of absorbent media we may separate these agencies and examine them in action in an isolated state.

A slice of obsidian, or of black mica, will not allow any Light to pass through it, but it offers no obstruction to solar Heat.

A plate of glass stained of an apple green with oxide of copper is perfectly transparent to Light, but it is almost opaque to Heat. Glass which has been stained yellow with oxide or chloride of silver allows a full flood of Light to pass

through it, but it will not admit of the permeation of an Actinic ray.

If, on the contrary, we take a glass coloured to a deep intensity of blue with oxide of cobalt, we shall find this is almost dark,—but little Light can pass through it. Experiment will, however, prove that it offers no obstruction to the chemical rays.

Now, if we place the most sensitive of photographic preparations in a room, the Light to which is admitted through windows glazed with yellow glass, howsoever brilliantly the sun may shine, though the apartment be flooded with light, chloride, iodide, or bromide of silver will remain for any length of time perfectly unchanged.

Glaze the room with cobalt-blue glass, which is so dark as to obscure the Light, these salts will blacken with great rapidity; proving that, although the light has been obstructed, Actinism has suffered no interruption.

The strength of evidence appears to be in favour of considering Light, Heat, and Actinism as three distinct principles or powers, active in regulating the great phenomena of Nature. In the sunbeam these powers are balanced against each other, and thus are determined those differences of climate which are not influenced by the physical conformation of the earth's surface.

It has been proved by well-conducted observations, that with variations of latitude there are variations in the relations of these three principles.

In the temperate regions of the earth the Actinic power is active; as we advance to the Tropics, where Heat increases, and,

"The sun shines for ever unchangeably bright;"

the chemical power is weak. The photographic picture which could be taken in London in a second or two, could not be obtained within the Tropics in less than a quarter of an hour. It often happens, indeed, that prolonged exposure under a blazing sun is insufficient to produce any chemical change. Everything appears to favour the view that the distribution of plants and animals on the surface of the earth is regulated by the balance of physical forces in the sunbeam.

In the Seasons we detect the same influences at work. Actinism or chemical power is greatest in the Spring; as the bright Light of Summer advances, the power of the Solar rays to produce any chemical change is diminished; and as we advance to Autumn, the peculiar Heat-rays come more evidently into action.

The ethereal agencies at work in the sunbeam play a most

important part in regulating all the conditions of vegetable life. Of many of these, experiments have determined the facts; a large field for inquiry is, however, still open to the industrious and patient searcher after hidden truths. The influences of Light on the animal economy are rather suspected than known. Experiments on animals present many difficulties which have not yet been overcome. Everything, however, proves the correctness of Lavoisier's poetic expression, "The fable of Prometheus is but the outshadowing of a philosophic truth—where there is Light there is organization and life; but where Light cannot penetrate, there Death for ever holds his silent court."

Light, Heat, and Actinism, existing in the sunbeam, are unceasingly at work. It has been shown by the investigations of the elder Niepce, and by Niepce de St. Victor, that it is impossible to expose any body, however solid and persistent it may appear, to the influence of sunshine without its undergoing a molecular or a chemical change. Glass, stone, wood, or metal, are, it can be proved, susceptible of Actinic change. The images of objects can be obtained upon them without any sensitive preparation; but they cannot be retained. In darkness all bodies appear to possess the power of restoring themselves to their normal state. If the solar rays shone *without interruption* on a granite monolith, or a bronze statue, it would perish, independently of other influences. Night is, therefore, as necessary to secure the permanence of the inorganic world as darkness and sleep are to maintain in healthful life the organized creations.

THE ENGLISH CALIFORNIA.

BY G. P. BEVAN, F.G.S., EDITOR OF "MURRAY'S HAND-BOOKS OF NORTH AND SOUTH WALES," ETC.

NEARLY all my readers have at one time or another seen a nugget—have handled it, wondered at its weight, and possibly its shabby appearance, and have involuntarily connected it with the arid hills of California and Australia, with hordes of undisciplined rapparees and savages (all the worse for coming from a civilized country), with tales of distress, starvation, robbery, and murder, with ne'er-do-weels, whom they formerly knew leaving the old country poor, and returning rich, after a few years' absence, with portmanteaus full of nuggets and carpet-bags full of gold-dust. But it has probably never struck them, that the same geological circumstances which have produced the material of those nuggets in a distant hemisphere have operated at home in our quiet British isles: in other words, that gold has been found and is to be found in no inconsiderable degree in some of our most picturesque and lovely districts, and that a simple question of quantity has prevented the English diggings from becoming the scenes of the same wild extravagance and of very wantonness of riches which have characterized those of Bendigo and Ballarat. Such is the case, however; and I will endeavour to show in this paper the geological conditions in which this, as any other gold produce, is found, and how far it is likely to become another ingredient of the permanent mineral wealth of this country.

Geologists have divided the whole of the rocks of the earth's crust into three portions, viz., Palæozoic, or Primary, implying the first and earliest division, as classified according to the fossil inhabitants in it; 2. Mesozoic, or Secondary, meaning the rocks which contain the middle zone of life in the earth's history; and 3. Cainozoic, or Tertiary, by which we understand the youngest and most modern of the divisions. For simplicity' sake we call them Primary, Secondary, and Tertiary, each of which is subdivided into numerous strata according to their fossil contents. It would be out of place to describe or even to catalogue the whole of these subdivisions,

and my only reason for mentioning them at all was to lay down a general rule, as applied to gold, viz., that it is never found in strata of Tertiary age, and but very rarely in those of the Secondary periods (except in the form of drifts, derived from older rocks). Indeed, as regards the Primary strata, it is almost always limited to rocks of the Silurian era, although it is occasionally observed in Carboniferous (coal-bearing) and Devonian (or old red sandstone) localities. We therefore perceive that the chance of finding the precious metal is at once considerably diminished by being limited to that portion of the earth's surface which is represented by Silurian, or perhaps, to speak more broadly, by primary rocks. The principal auriferous regions of the present day are the Oural Mountains of Russia, California, and Australia; and a few brief remarks on these goldfields may not be out of place, preparatory to detailing the position and features of our English gold.

We will take the Oural Mountains first, because they have been known and worked the longest, and are to a certain extent connected with Europe; besides which, they have had the advantage of being well examined and described by Sir Roderick Murchison. The enormous level area of Russia in Europe is occupied for the most part by primary rocks, and contains no gold; but, oddly enough, the same rocks, when thrown up into the broken and inclined positions which constitute the Oural chain, are auriferous in a very considerable degree. These upheaved ridges bear traces of great disturbance, and are pierced and permeated with porphyry, greenstone, syenite, and other plutonic rocks, the products of igneous action.

But here we have, as we shall see in the other cases, the great secret of the gold deposit, or, I should more correctly state it, as the infallible condition which accompanies the deposit, viz., the presence of porphyry or other igneous rocks in primary strata—a condition which will possibly give us a clue as to how gold is formed. The Oural hills are nearly all composed of strata of Silurian, Devonian, and Carboniferous age; and the gold was evidently not segregated or deposited at the time of the formation of these rocks, or else why is it not found in the contemporary districts of Russia in Europe? Moreover, Sir R. Murchison distinctly proved, from geological appearances on the flanks of these mountain regions, that the gold did not make its appearance until a very recent geological age; in other words, that the intrusions of the igneous rocks and the appearance of the gold were contemporaneous and recent. This is not merely a question of scientific interest, but bears heavily upon the more practical one of working the gold, as we shall presently see. The gold-bearing hills of Australia are very similar to those of Russia—the rocks which lie under the drifts

of gold being all sandstones, clays, slate, and grits belonging to the Palæozoic period. So much for the strata which produce the gold. Now we have to consider the position in which the metal is found and worked; and at the very outset we arrive at a practical conclusion—one which has been attained by many, many failures, and much bitter experience, viz., that it seldom or never pays to sink shafts for gold, since it has been proved in all the auriferous districts, that the richest find will be at the surface, and that the lower the adventurers sink the poorer in quality and less bountiful in supply becomes the precious metal.

The natural question then arises, as to the position of these drifts which have yielded so much gold and made so many fortunes. Let us, therefore, go back for a moment to the Oural Mountains. Sir Roderick tells us that the chief source of the metal is the accumulation of drift on the sides of the mountain, or the alluvium of the water-courses which descend to the valleys through the gullies; and the reason of it is this:—We must imagine a number of peaks and ridges permeated with intrusions of porphyritic rocks, &c., and impregnated with gold.

Denudation has largely taken place at one time or another, so that the outlines of these ridges have become altered, and a large quantity of material carried away and ground down to detritus of different sizes. It happens that, in the Oural chains particularly, we can fix the date of this grinding or denuding action, viz., at the period of the great glacial drift—a comparatively recent period, in which, nevertheless, the whole of the northern countries of Europe and Asia were permanently altered, from the ineffaceable quantities of material carried southward by the waters and icebergs of this Arctic period. We know, also, that what are now the northern portions of the continents were then inhabited by a singular kind of elephant and mammoth, adapted to the severity of the climate in which they lived; and accordingly associated with the heaps of gold-bearing detritus in the Ourals are found bones of these extinct animals, proving beyond all doubt the age of the drift. It is, therefore, not difficult to imagine why it is that these superficial gold-drifts are the richest, because not only do they bear in their bosom the materials from the surface of the veins which we have already seen is the most valuable, but the expense and labour of extracting and working the gold are as nothing compared with the expense of sinking shafts into the solid rock. Indeed, so well is this understood, that there is only one locality in the Siberian chain worked *sub-terrâ*, and that very sparingly. In Australia we find the same broad features, viz., that the gold-fields are in reality drifts of gold derived from the slaty primary rocks, and that the immense treasures extracted from them

have not been obtained as a rule by gold-mining, but from the surface. As might be expected, the finds have been most abundant in the creeks, gullies, and gutters of the now familiar mining language. But the drifts of Australia differ from those of Russia in being of a more remote age, although still considered to belong to the Tertiary period; and, indeed, Mr. Selwyn, the colonial geologist, has pointed out gold-bearing superficial drifts of three different stages or ages lying above one another, the oldest or lowest containing cones and traces of vegetation allied to that now prevalent in the country. But I have said enough to show my readers the usual disposition of the auriferous strata, and the conditions under which they are practically useful; and we will now come nearer home, where we find the gold in its original matrix in the solid rock; but, unfortunately, none of those fabulously rich reefs for the treasures of which so many people are annually risking their lives. And yet I do not know that I should say *unfortunately*, for if we have not the gold (which is limited and capricious), we have abundance of what is to us and the world in general, far more valuable—minerals, in the shape of iron, tin, lead, and copper, which not only create a steady market in themselves, but are the means of employing tens of thousands in the manufactures to which they give rise.

Every tourist in North Wales knows the lovely little town of Dolgelly, with the mighty mass of Cader Idris, at whose base flows the noble estuary of the Mawddach, dividing it from the great block of Merionethshire hills, stretching southwards from Harlech to Barmouth, the craggy Rhinogs, Craig-y-dwrg, and the broad slopes of the Llawlech, forming altogether a singular chain of mountains abounding in wild scenery that deserves to be more sought after than it is by the traveller. On the eastern side of this range is the wooded valley of the Cayne and Camlan, with their magnificent waterfalls, the most attractive lions of the Dolgelly neighbourhood.

Now this great Llawlech block is composed of a mass or boss of Cambrian rocks, which, in geological sequence, occur at the very bottom of the Silurian series, and are unfossiliferous, or nearly so. On each side of this Cambrian boss are layers of rock, known as Lingula flags (so called from containing the Lingula, a minute fossil shell), which, by a phenomenon known as an anticlinal line, are thrown off on each side, just as the coats of an onion might be. Above these Lingula flags are other Lower Silurian strata mixed up and interbedded with igneous rocks, such as porphyry, greenstone, &c. Here, then, we have the very sort of district which, as we have seen from Sir Roderick's observations, gold affects—a district of primary traversed by eruptive or igneous rocks; and here, accordingly, gold is found in about

twenty or more localities. At the Clogau mine, which is the most prolific and is still worked (situated 1,000 feet above the sea), they found a regular gold lode; not, indeed, of solid metal, but composed of quartz rocks, impregnated with ores of sulphur, iron, lead, and (very richly) with native gold, which occurs partly disseminated through the mass, but frequently in strings or "bunches." Mr. Readwin tells us that this was once worked as poor copper ore, and that the Flintshire copper smelters were averse to leaving it off, and even offered five shillings a ton more for its continuance! At the adjacent mine of Dolfrynog, Professor Ansted found gold also, occurring in grains and in thin flakes, together with crystals of galena (lead ore) and copper pyrites. The existence of this gold has been known for a long time, and various attempts have been made to extract it profitably; but somehow they have all failed, owing to the great cost of labour and machinery; for we must remember that we have not here the rich gold-bearing drift, although, by the way, a very slight quantity of gold was discovered in the marine drift on the slopes of the hill. There are two ways of extracting the ore: one by chemical and the other by mechanical means. The latter has been the most in vogue, and consists simply in extracting masses of quartz, and then crushing it by machinery. This was tried at Dolfrynog and also at Cwmhesian; but the costly character of the process soon made it anything but profitable; besides which, from the finely-divided state of the gold in the quartz and blende in this neighbourhood, it is almost impossible to prevent its escape during the operation of stamping. Mr. Dean, in a paper read before the British Association, in 1844, declared that the whole of the Snowdonian frontier was replete with auriferous veins; and it is certain that a company was started at Frodsham, in Cheshire, for procuring the quartz from North Wales, and crushing it here, with a view to extracting the gold.

The chemical mode is by amalgam, in which a certain quantity (by weight) of metalliferous mineral is triturated or ground up with so many pounds of mercury, on the principle that gold always exists in a metallic state, and that when it is present in minerals the mercury will dissolve it. This, however, was frequently a failure, owing to the mercury being capricious, and neglecting the gold to consort with other and less dignified minerals. The process is, nevertheless, used at Clogau, care being taken not to intrude any mineral which would neutralize the affinity of the mercury for the gold. The grand point, after all, is the result which has proved so successful in the patient hands of Mr. Readwin, who has for many years been experimenting on these Welsh ores, feeling certain that a practical gain was to be obtained at some time or other.

The experiments were conducted on quartz obtained from the Clogau mine, 1 cwt. of which was crushed and tested, producing eight ounces and five pennyweights of fine gold, the value of which is rather more than £3 per ounce.

From the same mine had also been produced 207 tons of quartz, 191 of which gave 241 ounces; 12, of better quality, gave 96 ounces; and 3 tons of best quality the enormous amount of 976 ounces: the whole quantity amounting to 1,314 ounces. This, together with an experiment on five tons a little before, yielded a total of 1,370 ounces, valued at £5,300; the cost of obtaining which he estimated at £300. There are, of course, exceptional cases, but sufficient to show what may be done; though, taking the bad with the good, Mr. Readwin considers half an ounce of gold to the ton of quartz to be the average yield. The total proceeds of gold for the last Christmas quarter amounted to £4,796, which he expects will be the average quarterly yield for the present year. With these results, we are surely justified in considering gold-mines as one of the staple products of our island: not to be looked upon as a treasure for fortune-seekers wherewith to indulge the "auri sacra fames," but, like all other mining ventures in this country, as another opportunity for the application of steady perseverance combined with the highest scientific knowledge and application.

CAVERNS AND THEIR CONTENTS.

BY D. T. ANSTED, F.R.S.

CHAPTER II.

CONTENTS OF THE CAVERNS, AND THEIR MEANING.

IN an article on "Caverns," in No. II. of the POPULAR SCIENCE REVIEW, something has been said concerning the history of these curious and interesting natural phenomena, and also of those remarkable columns, curtains, and fantastic structures of stone that are constantly growing and becoming modified in them by the action of water. It is also well known that occasionally caverns are the channels by which concealed rivers pass along out of sight from one part of the earth's surface to another; that sometimes the sea washes through them during a part of every tide; that some have, in ancient as well as modern times, served as the habitations of men or the dens of wild beasts; while others, only accessible from above, and only entered accidentally by any of the larger animals, are filled with stones and rubbish, with which valuable minerals and metallic ores are now and then associated.

The contents of caverns, then, is a part of the subject as varied as the history of the caverns, and capable of yielding quite as much matter of interest and information. We may consider in succession the mineral, the vegetable, and the animal contents, ranking among the latter those specimens of human art that have lately been found buried with the bones of animals.

Limestone caverns are not unfrequently mineral veins. The gaping crevices, partly filled with angular blocks fallen in from above, and partly with fine mud, have the interstices between the stones often occupied by glittering lead ore; or perhaps the floor consists of that stony ore of zinc called calamine, which seems to have been known only to the ancients as useful to convert copper into brass, and was not recognized by them as containing a specific and somewhat remarkable metal. Exposed to great heat, this stone-like mineral disappears as a white cloud (oxide of zinc), passing away into thin air. So

few of the common metals are volatile, that one can hardly be surprised at metallic zinc being a comparatively modern discovery.

Caverns in other rocks contain other minerals. In some of them native silver shoots forth from the walls in elegant strings, or the mixed ores of silver, lead, and antimony, with other less-used metals, are crystallized in various complicated shapes. Elsewhere, black, sooty walls mark the presence of manganese; and occasionally ores of copper, of extreme beauty, occupy niches in open spaces in slaty and granite rocks. But the great masses of valuable ores are not in caverns of the ordinary kind; and the mineral contents of caverns are more likely to consist of an irregular floor of stones bedded in mud than of gems and metals.

The vegetation found in caverns is less varied and less remarkable than the mineral wealth. A few ferns—some rare and curious, others common, but not less beautiful—are often pendent like a rich green fringe near the entrance and from the roofs and walls of those caves which open to the sea, while a floor of varied and tangled sea-weed marks the extreme point to which the ordinary tidal wave has access. One fern in particular, the sea spleen-wort (*Asplenium marinum*), though generally rare, is sometimes plentiful enough in such localities, and may be found in caves near Tenby, and elsewhere on the Welsh coast, and also abundantly in Devonshire, Cornwall, and the Channel Islands. Others have been found associated with it.

Owing to the darkness that prevails during the day as well as at night in the recesses of caverns, there is little growth there of any kind; nor is it at all usual to find much vegetable matter drifted far in. All that grows or is deposited near the entry of a cave is pretty sure to be found also on the rocks of the same nature close at hand, and offers little or nothing that is peculiar in its mode of growth.

Even in the animal kingdom the variety of species permanently inhabiting the recesses of caverns is very small. What there is, however, is curious enough; and these permanent residents deserve some notice before we pass to the principal subject of the present chapter, namely, an account of the creatures that have in old times made caverns their dens.

Of all modifications and adaptations of structure, that of the very remarkable blind reptile found in several large caverns traversed by water, in different parts of the world, is certainly the most singular. This animal, the *Proteus anguinus* of naturalists, is a kind of salamander, or may be understood better as something between an eel and a tadpole. It is a foot long, of the size of a human finger, with four little legs, too imperfectly developed to be of any use as limbs. It has no

fins; but two curious coral-red crests, or naked gills, close to the fore-limbs, are combined with true lungs, giving the animal a double system for the aëration of the blood. Its jaws are well furnished with teeth, and its nostrils are large; but its ears are covered by flesh and skin, and the eyes are not only excessively small and rudimentary, but are also covered by skin, although represented externally by small points. This very curious little animal is aquatic in its habits, but can live perfectly well out of the water; and the species mentioned has only been found in the deepest recesses of the gigantic caverns of Adelsberg, in Carniola, where there is a subterranean river and lake. A somewhat similar animal is found in the mammoth cavern of Kentucky. As these creatures are carnivorous, there must evidently be a supply of other animals equally well adapted to live in perpetual darkness; but none have yet been described. It is curious to contemplate a whole creation probably deficient of an organ which seems essential to the happiness and health, if not the existence, of the rest of the organic world.

The animal life found in those caverns which are gloomy only, and not absolutely dark, and which are subject to the alternate flux and reflux of a large tide in a narrow sea, is beyond all comparison interesting, beautiful, and varied. The appearance of living and flourishing groups of sponge and coral, the numerous star-fishes and other radiated animals,—many of them very rare, the inconceivable multitude and variety of form and colour of the well-known sea-anemones, and the curious variety of marine worms,—all these, if seen for the first time under favourable circumstances of scenery and weather, produce combinations that no one can fail being interested in.

"In such spots," says M. Quatrefages, in his 'Rambles of a Naturalist,' "where every stone is a world within itself, I was able to contemplate, in its incredible variety, the domain of the lower marine animals: here I could admire, in all their glory, those unknown wonders of the deep of which even our best museums afford not the least idea; for these animal forms droop and, as it were, fade from view when they are removed from their native element. The *Turbo* (or top shell), the *Buccinum* (or Whelk) with its brown and white markings, and the *Balanus* (Acorn-shell) with its pyramidal plates, covered every stone and rock. In sheltered nooks I found the pretty little rose-coloured Cowrie and large Chitons, animals in which the back is covered by a solid cuirass composed of movable pieces like the greaves of old. Then there was the *Thetys*, a kind of sea-slug of a fine orange-colour, which bears its tuft of external lungs on the hindermost part of the back; and the *Haliotis** (ear-shell), with its nacreous shell surrounded by a triple row of fringes.

* This animal is common in the Channel Islands and on the French coast, but does not extend to the coast of Britain.

The vaulted roof of these caverns, formed by the crumbling away of the rocks, was clothed with a mammilated stratum of simple Ascidians, which live and die without moving from the same spot; while from this bright-red ceiling there hung, like so many girandoles, transparent crystal-like *Clavellinæ* and the bright *Botrylli*, whose conglomerated masses exibit the colours and translucency of the agate. The smoother stones were all covered with Compound Ascidians, which were spread over the surface in shining green, brown, red, and violet patches, interspersed with markings of geometrical regularity, which severally indicated the different family groups of these singular beings. Among the animals appeared thousands of Zoophytes, while Star-fishes of the finest carmine, and greyish-brown Ophiuras, with their five long and slender arms, lay hidden beneath the stones. Above them the *Flustra* spread out its little stony weft, *Sertularias* and *Campanularias* raised aloft their arborescent polyparies, resembling miniature shrubs, while the *Eschara* threw its microscopic cellules over the stems and fronds of the marine plants. Sponges of every form and colour were intertwined among the branches of the fucus and attached to the sides of the rocks, either in thick masses or in interlacing meshes of delicate net-work. Here and there the *Thetya* might be seen, its rounded lobes bristling with little specula, side by side with the finger-like masses of *Alcyonium* and *Lobularia*, while sometimes a *Holothuria* (or sea-cucumber), with its long, polygonal, whitish body, would slowly move across this living tapestry, by means of its sucker-like feet, spreading abroad its coronet of arborescent tentacles."*

Such are the living contents of marine caverns, not only in the little islands of the Chaussey Archipelago, as alluded to more especially by M. de Quatrefages, but in the wonderful Gouliot caverns of Sark, in the smaller but interesting caves of St. Catharine's, near Tenby, and in many others less celebrated on other parts of the coast of England and Europe.

But caverns are sometimes tenanted by other and very different races. In countries little cultivated, and where wild animals are common in the adjacent forests, the bear, the hyæna, and some other beasts of prey, occupy caverns as dens, or use them either as larders or as burial-places. Sometimes they bring in and deposit there the carcases of their victims, sometimes they would seem to retire there to die. The skeletons and bones accumulated from either of these habits are not unfrequently heaped in quantities almost incredible, and they are sometimes mixed with and sometimes coated with recently formed stalagmite. Elsewhere, bones, shells, and various remains of animals have been washed into caverns on the occasion of some unusual flood, or have fallen in from above with stones, boulders, or angular fragments of rock. The caverns are thus sometimes floored with bones near the entry; sometimes the deeper recesses are choked with them to a great depth; and

* "Rambles of a Naturalist," *vide supra*, translated by E. C. Otté, vol. i. p. 38.

sometimes they have been quite filled, leaving no room for modern additions.

The entrances to land-caves containing these remains of animals are usually on some hill-side; and even many marine caves, such as those very remarkable ones at Gower, in South Wales, have, as the only access, some hole seen halfway up a steep and precipitous cliff.

The singular caverns of Yorkshire and Somersetshire, and some of those in Derbyshire; the caverns on the banks of the Meuse, near Namur; those of Franconia, in Germany; those of Sicily, and many others very remarkable for their osseous contents, are unmistakably above the level of any running water in the vicinity. Most of them are more, many of them much more, than sixty feet above the adjacent valley, through which streams run. A question hence arises as to the mode in which water can have had access; and often there are no convenient paths by which a large animal could now drag its prey. There is thus suggested a difficulty which a little further investigation tends to increase rather than explain. The animals whose remains are so abundant are not merely now absent, but no account of their existence in a living state is handed down to us. Nay, so far from the species being either familiar or historical, we are inclined to suppose that they never could have lived in the neighbourhood so long as the land and water and the climate existed as they do now. Perhaps this idea is not quite so well based as people have generally believed. In England and Western Europe the animals whose remains are most common in caverns are a very gigantic species of bear, now nowhere met with, but more resembling the grisly bear of California than the black bear of Europe, and a gigantic species of hyæna, compared with which the largest existing species is not worthy to be named. Moreover, this hyæna is related much more closely to the southern type peculiar now to the Cape of Good Hope than to the hyænas of Abyssinia and Asia Minor. When, therefore, we find indications of a long succession of such tribes, and that they carried into their dens the bones, not only of deer and oxen and other animals now belonging to the surrounding country, but of some altogether gone and lost to us, there is additional reason for assuming that the caverns teach a lesson in the history of the world, and require special consideration.

Among the creatures that inhabited Europe at the time when the caverns, or some of them, were the dens of wild beasts, we must rank the elephant, the rhinoceros, a remarkable deer of very large size and with horns of enormous spread, and a distinct variety, if not species, of bovine animal, of which the Aurochs of the Lithuanian forest is the nearest type. That

such animals ranged over the Continent and occupied England at a period not very remote in comparison with the general history of the earth, there can be no doubt. That they were abundant and indigenous would seem equally certain. Whether dry land connected England with Europe, or whether there were means of which we know not, enabling the gigantic quadrupeds to journey from the one to the other land, it would be idle here to speculate; but at any rate they lived and died on the banks of rivers whose beds are now in many cases several fathoms below the position they formerly occupied, and the materials of the floors of the caverns were either drifted in by accident, or carried thither intentionally by contemporary animals.

While the caverns of Europe abound in the bones of such races as we have just referred to, it is extremely curious and interesting to find that an almost similar difference between the animals of the caverns and those of the green fields and forests existed at the antipodes. It is now several years since a number of remarkable caverns were opened in South Australia by Sir W. Mitchell, and yielded a result not less remarkable than those of Germany and England. In them, also, we find the bones of carnivorous and herbivorous animals mixed together. The carnivora were such as would carry dead prey into a den; the herbivora were probably the common quadrupeds of the plains. As, however, that part of the world (Australia) is now peopled by kangaroos and wombats, and some herbivorous quadrupeds of moderate size, all having the structure called *marsupial*,* so the caverns contain numerous carnivorous and herbivorous species, also marsupial, but of dimensions and proportions singularly gigantic, and all now extinct. Whether from some sudden or gradual destruction and replacement of species, or, which is much more likely, from some slow modification resulting from altered conditions of existence, there would appear to have been, both in Australia and in England, a state of the land vastly more favourable for the existence of the largest quadrupeds at the time just before the historic period, than has happened since, or that we have any evidence of at an earlier date. For some reason unknown, this time coincided with such a position of the entrances of caverns as enabled the wild and powerful carnivora to make use of them, and drag thither their prisoners. This period was not a brief one, and may have commenced very long ago, when the dif-

* By marsupial is meant that the young are brought into the world in a very imperfectly developed state, and are long afterwards carried about by the mother in a *marsupium*, or natural pouch. It is conjectured that the rarity of water in Australia, and the long distances animals are obliged to travel without this necessary of life, may be reasons for this provision.

ference of inhabitants was far greater than lately; but the conditions of existence changed but slowly during its continuance.

Judging from the present position of the entrances of many of the principal bone-caverns, there must have been a considerable elevation of extensive tracts in Europe since or during the period we refer to. Such an elevation must have tended to increase the quantity of land in the northern hemisphere, and in this way to modify and render less equable the climate of the temperate latitudes. As by degrees the change established itself, and large tracts of low flat land—the great plains of Germany—rose above the waves, and became clothed with forest,—the higher lands meanwhile becoming hills and mountains—one can readily imagine that the conditions favourable for these monsters may have altered; that different races, smaller but more active, took their place; and that, by the time the change had been completed, the elevation should have carried out of reach the former habitations. Certainly there are few cases known in which caverns near the present level, either of the sea or of the adjacent valleys, have been found to bear marks of the habitation of ancient tribes of carnivora.

In the south of Europe, and in somewhat earlier deposits also in the north, at least as far as Britain, there are very numerous remains of hippopotami, and in India the number of extinct species of this singular animal is wonderfully large. At the time when so aquatic a tribe, and one believed to require so high a temperature, could live in England and Northern Europe, there must at any rate have been a very different condition of things from that since prevailing.

South America also has its bone-caverns, and these are neither few in number, nor doubtful in their indications. What the various marsupials are to Australia, the equally special and well-marked edentates are to Brazil, and other parts of the vast tract of country between the Andes and the east coast of South America The sloth, the armadillo, and the ant-eater, are the characteristic animals. In the caverns and in the mud-banks, where there is no limestone at hand to be penetrated and eaten away into holes, we find the ancient representative of these modern tribes. The difference here, however, is even more marvellous in extent than either in Europe or Australia, though similar in kind. In the place of the sloth, we have giants as remarkable for their massive proportions as for their size, though in that they exceed the elephant. Instead of the armadillo, there is a creature whose cuirass is not only larger, but harder and tougher than that of any living animal supplied with such defence. So also the ruminating animals are represented in similar proportion; and all point to con-

ditions eminently favourable for animal development, at least as regards size and proportions.

In South America, however, as in England, the caverns were occupied, and these monsters lived when the land was smaller, not larger than at present. Much of the width of those steppes that now conduct from the Atlantic to the foot of the Andes must then have been submerged, and have formed the ocean floor. The Andes were less lofty—the wall between the Atlantic and Pacific a less complete barrier than it has since become. The date of occupation of the caverns was one marked by great difference of climate, arising from great difference in the physical features of the land.

In alluding briefly to three principal districts of the earth as affording special evidence concerning the cavern period, it must not be supposed that bone-caverns are confined to them, or that there is reason to suppose that the occupation was contemporaneous. It does, however, seem certain that from a time when the present features of the land began to be developed down to a very late period, when men began to be civilized, there existed many races of large animals that have been destroyed, and also that, during the long time that elapsed, very important and extensive changes took place in the relative level of land and water, and in the physical features of the land.

The reader may be inclined to ask if any physical evidence exists of a sudden and violent disruption at any time of existing conditions, and a possible destruction of old and introduction of new races of animals. To this the geologist must reply in the negative. There is no such evidence in any part of the world on a scale large enough to deserve attention. Local disturbances have probably been repeated frequently, but of any change affecting the whole surface there are no indications whatever.

Among the objects of interest found in caverns, those that have reference to the human race are naturally the most interesting. When, therefore, fragments even of the rudest kind that indicate human intelligence in their manufacture are met with in association with ancient bones, it is not surprising that much attention should be directed to the discovery. Few, however, hitherto, are the cases of this kind, except when it is easy to refer the fragments to a definite period. Occasionally there have been found spear-heads and other articles of metal, small fragments of coarse pottery, and even beads, proving that the caverns had been for a time human habitations or sepulchres. All these, however, have reference to people of whom we know that they had already advanced far in the pro-

gress towards civilization. They were people of known races, and in many cases their descent and origin may be traced.

Once or twice, however, it has happened that the mud of the caverns has yielded yet ruder, much less useful, but even more interesting, human remains. Mixed up with the bones of the great cave-bear, the huge cavern-hyæna, the elephant, and the rhinoceros, and weather-worn like other stones of the same material, there have been found numerous flint and other stone weapons buried under stalagmite, affording unmistakable proof that a far more ancient race of men—savages of whose origin and history we know absolutely nothing—must have preceded the men of the historic period by a number of years quite unmeasurable. That this time was very great is probable; but nothing more can be said as to its amount. That it was sufficient to allow of the destruction of numerous races of gigantic quadrupeds and the introduction of many new groups, may be said to be certain.

The objects thus found are simple; and they have been met with much more plentifully in gravel-beds than in caverns. In both positions, however, they tell the same tale. They are flints, or other hard stones, chipped by human hands into a form believed to be meant for arrow or spear heads. Occasionally, flakes or fragments of flint broken off by a single blow, or a little more elaborately prepared, are mixed with them. They are weathered and whitened like other fragments of similar mineral found near them in the same bed, bearing no marks of having been artificially broken.

One result would seem certain from these discoveries in caverns; namely, that some members of the human race lived long enough ago to have seen the singular group of gigantic quadrupeds briefly described in a former paragraph, and to have fought with them: they may even have inhabited similar caves.

On the other hand, however, it is equally clear that these large animals may have lingered in many parts of the world to a comparatively recent date. There is no positive evidence one way or the other. That it would take long to expunge from the world some of the largest tribes, and replace them by others, is probable, but not certain; and when it is considered that even up to the present time we are by no means sure whether the gigantic bird of New Zealand (the *Dinornis* or *Moa*) is really an existing or extinct species, the danger of dogmatizing on the absolute date of the final destruction in Europe of the bear, hyæna, elephant, rhinoceros, or huge antlered elk, is apparent.

Still, the association of man with such animals as those we have alluded to in the places where their bones are found is a phenomenon that does not seem to be confined even to the

latest part of their history; and the balance of evidence renders it probable that the human race in a very early stage of development has been much longer upon the earth than is generally supposed. How long that stage of non-development, or imperfect development, may have existed, there are, as yet, no means of determining.

What a singular history, then, do these caverns afford, and how important is their geological bearing! One can imagine no good reason why those which were once inhabited should be limited in date to a period so recent as to include among their inhabitants the contemporaries of man; and yet, although they exist, and are even abundant, in the older limestones,* no trace has ever yet been found in them of the inhabitants of the land during any more ancient part of the earth's history. In the rocks themselves there are proofs enough of near land; quadrupeds, birds, and land shells, besides numerous fragments of land vegetation, are found there; and the land must have been not only near, but tolerably extensive. Why, then, is it that no fragments of the gigantic saurian or the marsupial rats of the middle period are met with among the mud at the bottom of the caverns?

To questions like these but little answer can be given. It may be that such vestiges really exist, but remain as yet undiscovered. It may be that the entrances to the caverns were not conveniently placed with reference to the general level of the land and water at the time. When the entrance to a cavern is below the water, or high up on the steep face of a cliff, whether above the level of the sea or a river, it is clear that there will be few remains of the life of the period preserved within its shelter.

And coming nearer to our own time, the question will also be asked,—What manner of men were these ancestors of ours—these indigens who inhabited the holes in the rocks, or who made use of them for storing their implements or burying their dead? Here, again, the answer is little satisfactory, but the facts are eminently suggestive.

Concerning the various weapons, or tools, or whatever else the human remains buried with hyænas' and bears' bones may have been, one fact is very significant, namely, that in all parts of the world—in England and France, Germany and Italy, Russia and Scandinavia, everywhere, in a word, throughout Europe—these remains, wherever found, are in all essentials the same, and are not unfrequently of foreign material. This, of itself, is interesting; but when we find that from the interior

* The limestones of the carboniferous period contain by far the most remarkable of the caverns in England and Wales and North America. The oolitic limestones are chiefly caverniferous in Germany, and tertiary limestones in Sicily.

of India and China, the banks of the Mississippi, and the vast plains of South America, specimens of sculptured stone are obtained always precisely similar—that the jade of the East is mixed up in the caverns and gravel with flints from Western Europe, and with greenstones from America, and that even the northern parts of Australia and Madagascar appear to contain examples of manufacture differing from these nothing in style and little in material—we are reminded pointedly of the original unity of the human race, and we see that an undetermined question of time forms the only serious difficulty interfering with the reception of one of the most startling innovations resulting from modern geological investigation.

Caverns, then, teach many truths in geology. First of all, they point, in their very form and in the mere fact of their existence, to the grand operations of nature carried on out of our sight in the deepest recesses of the earth,—the conversion of mere heaps of mud and sand into definite stratified rocks, hard, durable, and characteristic. Next, they teach us how, when the rocks have been elevated, water has acted upon them not only externally, but widening the narrow channels, removing and clearing out large spaces, and again filling them up with different material. Thirdly, they show the nature of the inhabitants of a former state of the earth's surface, when climate and other physical causes determined the presence of races that have long since departed. Fourthly, they lay bare, sometimes in the most singular manner, the secrets of marine life, and invite to a study of nature under circumstances of peculiar variety and interest. Fifthly, and lastly, they tell us a part of the great story of human existence, and of the association of man with many extinct races of gigantic quadrupeds, known only by their skeletons, but certainly characteristic of a geological period.

THE MICROSCOPE;

WITH DIRECTIONS FOR ITS USE.*

BY CUTHBERT COLLINGWOOD, M.B., F.L.S., ETC.

IT may be said that there is scarcely any instrument of a philosophical character which, placed in the hands of one unaccustomed to its use, at once suggests the method of its satisfactory application. Explanations are necessary, methods of manipulation have to be pointed out by some one who has already mastered its details, and learned the uses of the various parts, and the practical application of the whole. And particularly is this the case with an instrument so complicated as the Microscope, the beautiful adaptations of which may be missed in the absence of a guiding hand, the results impaired for want of fully comprehending the means of arriving at them, or the delicate parts may be injured by the too rough usage of an inexperienced tyro. It has sometimes been our lot to meet with persons who, surprised at the marvels, or delighted with the beauties of the natural objects that have been casually shown them through the Microscope, have forthwith determined to be themselves the happy possessors of so enchanting an instrument. The Microscope, obtained perhaps at great cost, arrives, is unpacked, and the source of a thousand innocent and intellectual gratifications stands before its owner, a useless machine, for he has not the skill to use it, and perhaps is almost afraid to touch it, lest he should do it some injury. The beautiful objects seen through the previous instrument cannot be observed by this, or are only so partially and obscurely viewed as to give rise to blank disappointment. He may, perchance, know no one to whom to apply for an explanation of the various parts, and disappointment is followed by vexation, and the instrument laid aside in disgust, just for the want of a hint or two of a practical nature, the result of which could not fail to stimulate further inquiries. It is to such of our readers as may be thus situated that the following pages are addressed,—to *beginners* with the Microscope, who are in search of some brief

* We publish this paper at the request of numerous correspondents.

but plain directions *how to use it;* and it is hoped not only that a short paper on this subject may not be unacceptable to those who are thirsting to explore the boundless field of minute organic life, but that others may be induced by its perusal to possess themselves of an instrument with which they may thus at once, and with little difficulty, render themselves familiar; so that the band of scientific investigators may be reinforced, and the mass of valuable results be increased.

The great optical principle which lies at the foundation of the Microscope is termed *Refraction.* By this term is expressed that change in its course which a ray of light makes in passing from one medium to another in an oblique direction. If a piece of stick be dipped perpendicularly in a basin of water no distortion appears, but the stick is seen to be straight as in the air. Depress, now, one end of the stick, and the part which is immersed in the water appears bent or distorted. The ray of light (or the stick) passing obliquely from the rarer medium (air) into the denser medium (water), is bent in such a manner as to approach *towards* a plumb-line let fall through the point where the air, water, and stick meet. It follows, therefore, that the ray which passes in the other direction, namely, from the water (the denser medium) into the air (the rarer), is bent in the opposite direction, namely, away from the perpendicular plumb-line; while the light which passes in the direction of the plumb-line itself, in or out, undergoes no contortion, bending, or refraction. The same thing that happens in the passage of a ray of light from air through *water,* takes place in its passage from air through *glass,* only glass being more dense than water, the refraction produced is greater. Taking advantage of this simple property of light, pieces of glass have been constructed of such forms that the rays of light received by the whole surface of one side are so refracted that they all meet at one point (termed the focus) on the other side; the distance between the centre of such a piece of glass and the focus being termed the *focal distance.* Such a piece of glass, termed a lens, *magnifies* by enabling the eye to see the object at a shorter distance than would otherwise be possible, thus causing the rays of light from the object to enter the eye at a wider angle, and thereby enlarging the image impressed upon the retina. Those lenses which are convex on both sides, as an ordinary burning-glass, are most common; but in compound instruments, this form of lens is sometimes combined with others, as the plano-convex, plano-concave, concavo-convex, and double-concave.

A common pocket lens consists of such a double-convex lens, which has the same enlarging effect as a glass-bubble filled with water, one of the most ancient forms of microscope. Two or three such lenses combined increase the effect. But the great

difficulty to be overcome in the construction of such lenses is of a twofold character, viz., first, *spherical aberration*, or the distortion caused by the failure of all the rays to meet precisely in the focus, owing to the imperfection of the curvature of the lens; and *chromatic aberration*, which arises from the different degrees of refrangibility of the different coloured rays which unite to form ordinary white light. The first difficulty is surmounted only by more delicate and improved workmanship; the second, by an ingenious combination of different kinds of glass (as crown glass and flint glass), which possess different powers of dispersing the coloured rays,—the one correcting the other. For simple microscopes this contrivance at once obviated the inconvenience arising from the coloured fringes surrounding the image, to which the name of chromatic aberration was applied; but the minuteness of the lenses used in compound microscopes led even distinguished opticians to believe that these great difficulties could never be sufficiently overcome to render such compound instruments of any real service. The clearness of definition, and the absence of colour observable in even the higher powers now in use, afford sufficient proof that these fears have vanished before the advance of skill and science.

A *simple* microscope, then, consists of either a single lens, or of two lenses combined so as to act as one, and fixed upon a stand, so that it can readily be adjusted to an object, and at the same time kept more steady than it could be by the hand. A framework to support the object, and a mirror to collect the light upon it, complete the arrangement. Such a microscope as this, simple as it really is, is very useful for many purposes, particularly for the dissection of vegetable structures, or such objects as it is desired to tear up or anatomize under assisted vision; and it is to such an instrument as this that the earlier microscopic observers were indebted for those discoveries which laid the foundation of the present vast accumulation of microscopical knowledge.

The *compound* microscope, being the form now in general use, and for the perfection of which the ingenuity of the optician and the mechanic has been taxed to the uttermost, is that to which we would direct especial attention. Like the simple microscope, this instrument may consist of only two lenses; but these, instead of being simply combined to produce the effect of one, have totally distinct functions. One of these, nearest the object (the objective, or object glass), collects the rays from the object and brings them to a focus, producing an image, which is scrutinized by the other lens as though it were the object itself. This second lens is called the eye-glass, and the separation which is obviously necessary between these two lenses, and which is equivalent to the focal

distances of the two, produces a necessity for a tube or body in the compound microscope, which the single instrument does not require.

But in the completer form of compound microscope another lens is employed, which is inserted between the object-glass and the image produced by it. This glass serves the important purpose of so changing the course of the rays as to diminish the size of the image, thus allowing the whole of it to come within the range of the eye-glass, and enlarging the field of vision. Hence it is called the *field-glass.* It has, however, an important relation to the eye-glass, which, together with it, is called the *eye-piece.* (Fig. 1.) The most useful eye-piece consists of a plano-convex field-glass and a similar eye-glass, the plane surfaces of each being towards the eye, and a *diaphragm* or *stop* being interposed between them, so that only the more central rays are allowed to pass, the distortion arising from spherical and chromatic aberration being thus avoided.

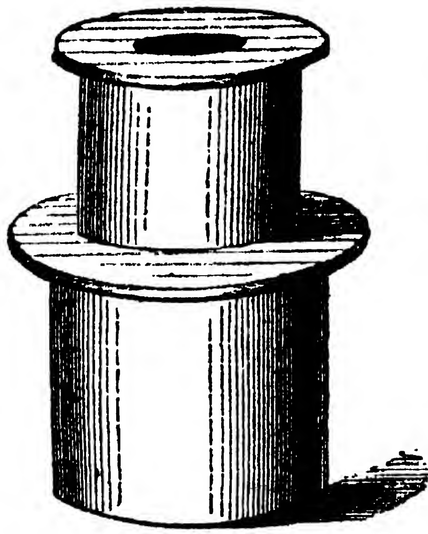


Fig. 1.

The general *optical* principles concerned in the construction of the compound microscope being understood, the various modifications and matters of detail must be mastered at leisure, being, in fact, not the sudden and easy application of principles long known, but the laborious and careful result of ceaseless experiment and research. But there are other principles to be applied, of a secondary nature it is true, but still scarcely less necessary for the efficient working of the instrument than those to which brief reference has been made. These are the *mechanical* arrangements, the stability of the whole apparatus, its capability of accurate adjustment, and the convenient mutual relation of all its parts. These, perhaps, will be best illustrated by a description of the various parts of an ordinary compound microscope, such as that of which a drawing is given at fig. 2.

In this microscope it is first to be observed that the tripod stand affords a firm basis of support, so that there is no fear of the instrument being readily overturned, or even moved by any ordinary manipulation. The two pillars upon which the microscope itself works are solid, and with the feet are altogether of a considerable weight, thus preventing any movement or vibration in the instrument, which is securely screwed between them. This is extremely important, since any vibration is communicated to the object in an increased proportion, according to the magnifying power used. The microscope itself consists of two

parallel columns united by a solid cross-piece; the lower column (suspended between the pillars of the stand) bearing the illuminating mirror, stage, rack-work, &c., the upper column being the body or tube of the optical instrument, with its objective and eye-piece. Fixed to the middle of the lower column is the *stage*, a flat table, having an aperture situated immediately in a line with the tube of the microscope, for the admission of light from below, which is thrown up by the mirror. The glass slide containing a mounted transparent object which is to be viewed by transmitted light, is placed upon this stage, being secured from slipping out of its position by a movable ledge which is readily adjusted so as to secure beneath the object-

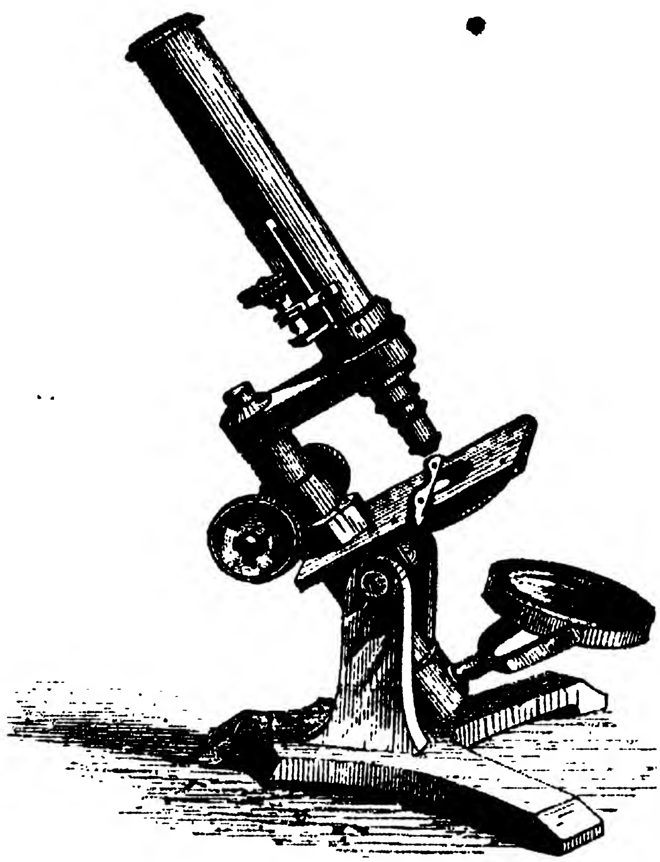


Fig. 2.

glass the particular portion of the object which it is desired to examine. This stage is sometimes furnished with a pair of milled-heads which move it forwards or sideways at pleasure, so that any moving object may be kept in the field without the necessity of touching the slide or cell containing the object. Immediately beneath the stage is a circular plate called the *diaphragm*, with perforations of various dimensions, from the size of a pin's head to that of the aperture in the stage itself. These openings regulate the amount of light admitted, very transparent objects being scarcely discernible in the full glare of light admitted through the large apertures, which, however, are necessary for the examination of objects of a more opaque character, which require all the light obtainable. At the foot of the column is the concave mirror, which, being

moveable in all directions, throws up the light which it reflects from a window, or a lamp, upon the transparent object which it thus illuminates from beneath. The upper part of this column is provided with a pair of large milled-heads, by turning which, the tube of the microscope, together with the solid cross-piece to which it is fixed, can be raised or lowered by means of a rack-work attached to a short stem which slides up and down in the upper part of the column. By this means the focus can be adjusted without the necessity of moving the stage, which in all the best microscopes is a fixture to the lower column. This is termed the *coarse adjustment*, and, for low magnifying powers, is all that is needed for regulating the focus.

The tube of the microscope itself, which is thus raised and depressed, has the *objective*, or *object glass*, at its lower extremity, and this can be unscrewed (fig. 3) and replaced by another power at pleasure; and at its upper extremity is the *eye-piece*, which is also readily pulled out (as at fig. 1), either for the purpose of cleansing it, or for the insertion of another kind of eye-piece. About midway up the tube is a small milled-head (seen edgewise) connected with what is termed the *fine adjustment*. A very slight movement of this milled-head alters the focus, when high powers are used, so that, having brought the object roughly into focus by means of the coarse adjustment, the utmost precision and the clearest definition may readily be obtained by a turn or two of the fine adjustment. Finally, in the description of this microscope only one thing more need be noticed, and that is, that the whole instrument is suspended (neither too stiffly nor too loosely) upon the two screws at the upper part of the pillars of the stand, so that it may be placed in a vertical, an inclined, or even a horizontal position, at pleasure, without moving the stand. This is an important advantage; for whilst various degrees of obliquity are often requisite to meet the convenience of the observer as he sits in his chair, or to take advantage of the position of the light, it is sometimes desirable to place the instrument in a vertical position, as when examining objects in water, while the horizontal is a no less useful position for certain purposes.

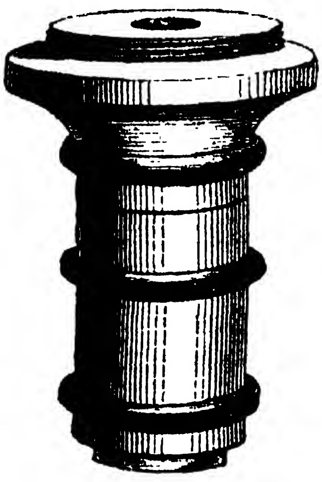


Fig. 3.

Let us now suppose the microscope placed upon a firm table, and the observer, with all his apparatus ready at hand, seated before a window. This leads us to make some remarks upon the *illumination* of the object. Daylight, when it can be used, is preferable to artificial light,—not direct sunlight, which is

too powerful, but strong, diffused light, which can be used with much more comfort than artificial light, and at the same time affords a more satisfactory view of the object under examination. But as it generally happens that the microscope is taken out when the busy labours of the day are over, some kind of artificial light is requisite; the great desideratum being a light which will not flicker, but will burn steadily, and give as pure a flame as possible. Gas may easily be brought down from the burner by an elastic tube communicating with a portable lamp upon the table; and, for those who have gas, this is, perhaps, the simplest expedient. The expensive solar and argand burners are, however, now in a great measure superseded by very inexpensive and manageable *paraffin lamps*. A lamp of this kind can be purchased at an oilman's or lamp-seller's for prices varying from one shilling upwards; a really elegant lamp, particularly when lighted, being obtainable for the small sum of two shillings, or half a crown. The oil burned in these lamps requires, however, a word of comment and caution. The ordinary cheap *paraffin* oil is liable to give off an explosive vapour, which might lead to serious accidents. A simple test of the quality of the oil is to pour a little of it upon a plate or saucer, and apply a light to it. If it take fire, it is dangerous; but if it does not burn, it may be freely used. By purchasing the oil termed *Belmontine*, however, all danger is avoided, and a pure light is obtained at a very small cost, it being only one shilling and twopence per quart. A lamp of this kind may be placed as near the reflecting mirror as necessary, and may be raised or depressed by blocks at pleasure; while the glare upon the eye from the lamp itself may be easily avoided by suspending a shade of cardboard, or other similar material, in front of the eye-piece of the microscope. By turning the mirror about, the light is easily directed upwards through the transparent object, and regulated, either by slight eversion of the mirror, or by the use of a smaller stop in the diaphragm. If, however, it be desired (as is often the case) to examine an object which is impermeable to the light thus thrown up by the mirror, another method of illumination becomes necessary. For this purpose the *condenser* (fig. 4) is employed. It usually consists of a large plano-convex lens, and is sometimes mounted upon the microscope itself, being readily turned aside when not used, or towards the object, when required, by means of a joint or elbow. In the larger microscopes, however, this condenser, or bull's-eye, is mounted upon a stand (as in the figure), upon which it slides up and down, the glass being fixed upon a stem which is received in a tube, thus allowing of its being freely turned in a vertical direction; while the tube itself admits of a horizontal

movement upon the stand. The lens can thus be raised or turned in any direction, the intention being so to adjust it as to concentrate the rays in a focus upon the opaque object under examination. The plane surface should be nearest to flame.

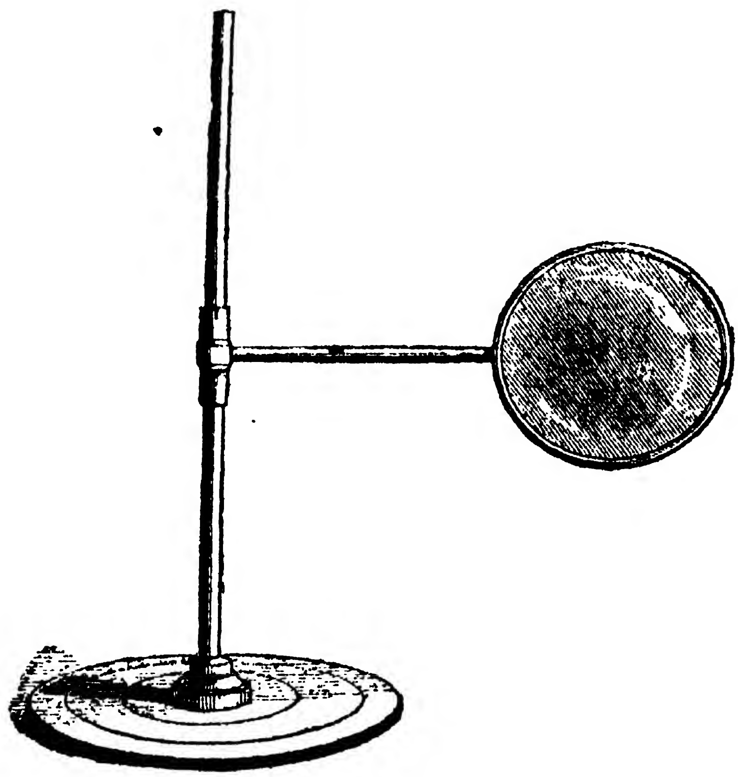


Fig. 4.

The position which the observer assumes should be one which is consistent with his own ease and comfort. In a constrained attitude he will soon tire, and physical fatigue will be followed by loss of interest and power of observation. The table, therefore, as well as the seat, should be regulated to meet his requirements, and such an obliquity given to the body of the microscope as may suit both. In looking for a long time down an instrument, the eye is liable to become fatigued, especially if the same eye is always used; it is desirable, therefore, that the observer should learn to use either eye at pleasure, and occasionally to change one for the other. But, since we are aware, from experience, that this is not always an easy matter, it will be well early to accustom oneself to keeping the unemployed eye open, by which means the fatigue arising from screwing it up with a constrained and constant effort, is avoided.*

The object-glasses vary in magnifying capability, and are hence called *powers*. Those whose *focal distance* is greater

* On no account should the observer continue the inspection if he feels pain or fatigue. Many microscopists have either impaired or destroyed their eyesight by too long continuance at the instrument, or by its too frequent employment.

than half an inch are usually termed *low* powers, and they are made as low as two inches (2-in.-power). If the focal distance is less than half an inch, it is a *high* power. Thus we have various powers, called respectively, *two-thirds* (of an inch), *quarter*-inch, *eighth*, and even *sixteenth*, though the last power is seldom used, and very liable to erroneous interpretation, even in the hands of experienced microscopists; and indeed the *eighth* is only necessary for the more recondite investigations. Useful powers, particularly for beginners, are the inch (fig. 3) and the half-inch, to which after a time the quarter-inch may be serviceably added. The magnifying power of these objectives depends upon the character of the eye-piece, of which there are sometimes three descriptions used, called respectively, No. 1, No. 2, and No. 3 eye-piece,—No. 1 having least magnifying power, and No. 3 the greatest. The two-inch objective with No. 1 eye-piece magnifies twenty times linear (or twenty diameters),—with No. 2 eye-piece, thirty-five diameters. The inch objective, with No. 1 eye-piece, magnifies fifty-five diameters,—with No. 2, one hundred. The half-inch with No. 1 eye-piece magnifies one hundred and twenty diameters,—with No. 2, two hundred and ten diameters. The quarter with No. 1 eye-piece equals two hundred diameters,—with No. 2, three hundred and fifty,—and the eighth, four hundred and fifty and seven hundred and sixty respectively.

In selecting one of these *powers* for the examination of any object, the observer must be guided by the *size* of the object. If of a considerable or appreciable size, it should be first scrutinized through a *low* power, which indeed may be found sufficient for the purpose, but if not, the next higher power may then be employed. If the object be very minute or imperceptible, the half or quarter-inch may be at once brought to bear upon it. And here let us remark, that in unscrewing and screwing on these objectives, some difficulty is apt to occur from the worm of the screw not easily slipping into the groove, particularly if the screw be a fine one; and the patience is sometimes severely tested by the delay. It often happens that this difficulty may be at once surmounted by giving the screw a turn in the wrong direction, by which means it is easily slipped into the groove, and may then be readily fastened.

To get the proper focus with a low power, all that is required is to turn the large milled-heads which move the tube of the microscope upon the rack-work, hence termed the *coarse adjustment;* but when high powers are used, more care is required in manipulation. The objective should be cautiously brought down by means of the coarse adjustment to within a short distance of the slide upon the stage, and then, with the eye at the eye-piece, and the finger upon the *fine adjust-*

ment, it must be moved backwards and forwards until the true focus is found, and consequent clear definition is obtained. But the fine adjustment has other uses besides merely *finding* the focus with a high power; with the finger upon it, and the eye at the microscope, the object should be well scrutinized, and each part or stratum of its thickness successively focused, the relations of these strata to one another only being satisfactorily determined while in the act of changing the focus. In using the *coarse* adjustment with high powers, the great thing to be avoided is heedlessly bringing down the object-glass upon the slide under examination, which an incautious turn of the screw may too easily accomplish, and which makes possessors of good microscopes very careful how they allow strangers to meddle with their instruments. The result of this accident may be either to break the glass slide on the stage, and totally destroy what is perhaps a valuable object,—or worse, it may result in a chip or scratch of a ten-guinea objective.

The young microscopist is very liable to fall into considerable errors of judgment while examining an object, particularly under high powers, arising from his inexperience and consequent inability to comprehend a distortion or recognize the truth. Nor need he lose courage at this, for experienced observers have fallen into similar errors of much more importance than any he is likely to make—errors which have given rise to false theories, and retarded the progress of science. Some of these errors, arising from optical appearances, can only be corrected by practice, or by the use of more complicated apparatus which the student will apply in the course of time. There are others, however, concerning which some hints may here be given. If the parts are not accurately in focus, the outlines may be either distorted, indistinct, or misrepresented. Lights and shadows may be completely reversed, as in the markings of the diatoms,* a circumstance which arises from the object itself refracting light. And the higher the power used, the greater is the liability to fall into this error. Sharply-defined black rings with a bright centre cause no little surprise to the beginner, which, however, are nothing more than minute *bubbles of air*. Oil-globules in water present much the same appearance; as also do globules of water, surrounded by a layer of oil. But if the object-glass be approached nearer to them, the water-bubbles and oil-globules get a darker centre, the water-globules in oil a lighter centre, and the reverse when the objective is raised. Such changes as these, as means of recognizing different substances often met with in the lower forms of animal and vegetable life,

* Lowly forms of life.

are useful lessons to the student. But for most errors of interpretation, the simplest remedy is the use of low powers until sufficient experience is gained to allow of higher powers being usefully employed.

In handling the eye-pieces and object-glasses, care should be taken to touch the glass surfaces themselves as little as possible, as they readily become dimmed by contact with the hands, or even by the moisture exhaled on too close an approach. A piece of wash-leather should be always at hand, as it is the best material for cleansing the glasses either from dust or moisture; and if any water is used, as in examining animals or vegetables in fluid, great caution should be exercised in keeping the object-glass dry; or if by accident it gets wetted, it should be wiped as soon as possible. This caution is particularly necessary when salt-water is used, and the microscope should be carefully cleansed of the least particle of it before being put away, otherwise unsightly corrosions, verdigris, and impaired action of the mechanical parts, will soon result. Indeed, every one who values his microscope will take the greatest care that it does not suffer from thoughtlessness, or inattention to such simple precautions.

In the foregoing sketch I have only alluded to such apparatus as may be regarded as essential to working with the microscope, but there are still many additional pieces which the student may with advantage add from time to time, as his experience or his wants increase. Of such accessory apparatus several are contrivances for improving the illumination, of which some are luxuries, and others are really useful, and even essential to the proper examination of special and peculiar objects by the experienced and professed microscopist. The *Lieberkühn speculum*, for examining opaque objects, and *Wenham's Parabolic Reflector*, for obtaining perfect definition under high powers, are examples of these. The *polarizing apparatus* I have altogether omitted, because any satisfactory description and explanation of it would have increased this paper beyond desirable limits; it can only be here stated that the polariscope is a useful addition to a microscope, particularly if it be chiefly used as a recreation, the beautiful chromatic effects which are produced by it being in the highest degree curious and fascinating; and even the scientific microscopist will sometimes find it of real service. *Micrometers*, glass slides with fine and regular lines for the measurement of minute objects—and finders, by means of which any special object of the minutest size may be at once placed under the object-glass, without the trouble of half an hour's search, are also useful additions. Other accessories relate to the examination of living objects. Usually, the prepared object is placed upon a flat glass; but if it is a minute living animal, it may be placed either on a thicker glass, hollowed out in the middle

for its reception, termed a *cell*, or in what is called a *live-box*, or *animalcule cage*, more particularly if the objects be swimming in water. For larger objects, such as zoophytes, or for showing the circulation in plants, a *glass trough* is necessary, which may be filled with water, laid upon the stage, and the object examined with a low power. For ordinary objects (not living), such as vegetable structures, parts of insects, &c., it is sufficient to lay them upon a flat piece of glass (or *slide*), and to place over them a round or square piece of very thin glass (made and sold for this purpose); and thus to examine them, either dry, or having first moistened them with a drop of clean water, which assists their transparency—care being taken to avoid air-bubbles between the two pieces of glass as much as possible, and to keep the upper part of the thin glass cover dry.

It now only remains to refer the student to some form of microscope which, not being too costly, will probably be within his means, but which at the same time shall be of guaranteed excellence, that he may not be tempted to waste his money upon inferior productions. In doing this it is manifestly invidious to single out any one name from a number of excellent makers, or to say which is the best of such manufacturers as Smith and Beck, Ross, Powell and Lealand, and others, when all are of such acknowledged merit. If we particularly allude to the first of these, it is because, besides the well-known excellence of their instruments, their less expensive microscopes appear to us to be adapted for the purpose we have in view. Their *Educational Microscope* is a portable, compact, and complete instrument, consisting of stand, mirror, spring-stage, condenser, diaphragm, two eye-pieces, and two objectives, viz., an inch, and a quarter inch, magnifying respectively, 55, 100, 200, and 350, linear. The price of this instrument is ten pounds; and for an additional five pounds, all the apparatus necessary may be secured, consisting of a Lieberkühn, parabolic reflector, polarizing apparatus, camera lucida (for drawing the magnified object), micrometer, live-box, and glass trough. This additional apparatus may be purchased at any future time. If the student is more ambitious, he may purchase the *Student's Microscope* with $\frac{2}{3}$ and $\frac{1}{5}$ objectives (reaching a linear magnifying power of 430), and apparatus complete, for £20. But for those whose means are more limited than either of these would imply, there is still an instrument, which may be within their reach, viz., *Field's Compound Microscope*, called the *Society of Arts Microscope.* This marvel of cheapness arose from a competition for an award offered by a committee of the Society of Arts, in 1854, for a low-priced compound microscope which should combine cheapness with the greatest degree of excellence. The award was made to Mr. G. Field, optician,

Birmingham, who is bound by agreement with the Society of Arts to keep the instrument always in stock, and supply any purchaser at once. It has two eye-pieces and two achromatic objectives, varying in power from 25 to 200 linear, a condenser on a separate stand, coarse and fine adjustment, stage-forceps, and live-box; and the whole, in a mahogany case, may be purchased for *three guineas.*

Finally, for further information upon the subject of the optical and mechanical principles of the microscope, manipulation, apparatus, collection and mounting of objects; and for an elaborate illustrated description of the microscopic forms of animal and vegetable life, we cannot do better than recommend Dr. Carpenter's work on "The Microscope and its Revelations" (price twelve shillings and sixpence) in Churchill's series of scientific manuals.*

* Useful little French microscopes for beginners with limited means may be purchased for ten and sixpence (walnut-wood case included); and for such also Dr. Lankester's little work, "Half-hours with the Microscope," illustrated by Tuffen West, F.L.S., will be found serviceable.—Ed.

CONTRIBUTIONS TO THE HISTORY OF THE ROTIFERA, OR WHEEL ANIMALCULES.

BY PHILIP HENRY GOSSE, F.R.S.

PART III.

THE BUILDERS (MELICERTADÆ).

NO aspect of natural history is more attractive, none at least takes a stronger hold on the minds of general readers, unsophisticated with mere technicalities, than that which presents the inferior creatures in the exercise of their manifold instincts. We are never tired of reading well-authenticated narratives of the manners of animals, their "sayings and doings;" their actions in ease and under the pressure of circumstances; their affections and passions towards their young, towards each other, towards other animals, towards man; their various arts and devices to protect their progeny, to shelter themselves from the weather, to procure food, to escape from their enemies, to defend themselves from attacks; their ingenious resources for concealment; their stratagems to find, to come up with, to waylay, to overpower their victims; their modes of bringing forth, of feeding, and of training their offspring; and a thousand other details of what is properly called their *history*.

What materials for reflection, what incentives to praise—adoring, admiring praise—of Him who is *maximus in minimis*, do we discover in a bird's nest! How varied, how incongruous, in many cases how apparently unsuitable are the substances used; how few and simple are the implements employed:—

"No knife to cut, no bodkin to insert,"—

yet how perfectly is the work performed, how completely is the object attained! So compact, so firm, so warm, so tight, so well secured, so well concealed!

The beaver—which associates with its fellows, to hew down with patient toil the massive trees, and then forms, with admirable

engineering skill, strong dams across rapid streams, and builds covered houses which contain dwelling-rooms, sleeping-rooms, nurseries, and larders, communicating with one another, and covered by a common roof—must ever be surrounded by a halo of romantic interest, scarcely diminished by the slight pruning which the accuracy of modern research has inflicted upon older exaggerations.

How marvellous are the instincts of the termites or white ants of the tropics, which, uniting in armies of myriads, build great stony structures of cement manufactured by themselves, including various chambers and galleries, carry arched tunnels under ground, make long covered ways, and throw light but substantial tubular bridges across hollows!* And how additionally marvellous is the marshalled order in which these hosts are arranged; not forming a promiscuous multitude, but divided into ranks, as strongly defined and as permanent as are the castes of India or Japan;—the royal pair nourished with loving care, and housed in capacious domed apartments; the soldiers ever ready for warlike attack or defence, but never making the slightest attempt to build or repair; the labouring millions unfit for battle, but ever ready with their assiduous skilled labour to erect or enlarge or repair the common edifice, or to collect food for the common sustenance!

Scarcely less curious, and more celebrated, are the social and architectural instincts of the hive-bees and the paper-making wasps. These, though they do not display the same elaborateness of class-division as the termites, yet have claims to admiration peculiarly their own, in the perfect mathematical regularity with which they form their dwellings, and the materials which they employ in the construction,—wax in the one case, paper in the other, each substance being collected in a crude state, and then elaborated by the insects themselves.

In the woods of Southern Africa the traveller meets here and there with trees, the trunk and principal branches of which are inclosed in a vast dome of thatch, suggesting the thought that a large barn had once stood on the spot, but that a tree had grown from the area through the roof and lifted it from the walls, which had then fallen and disappeared. It is the residence of a colony of birds,—the sociable grosbeak—which, five hundred to a thousand in number, build their nests in crowded proximity, and protect the whole with this well-compacted thatch of native grass.

Yet another species of the same tribe of birds,—the pensile grosbeak,—inhabiting the same regions, associates in like multitudes, but builds habitations of more elegance, which we may

* Smeathman, *passim*.

liken to detached villas rather than to the crowded houses of a town. For the nests of these little birds are long purse-like structures, curiously woven of reeds and grass, in the form of long bags, with the entrance-hole at the lower end, suspended from the projecting boughs and twigs of some wide-spreading tree, generally over a river or other water. Several hundreds of these "tree-rocked cradles," all separate, though in close proximity, have been observed depending from the branches of one tree.

Two forms of instinct are presented to us in these examples, which, though often conjoined, are yet distinct. There is the constructive instinct displayed in strong development, and there is the instinct of association. In multitudes of cases we find these two tendencies acting separately. If there are social bees and wasps, there are solitary species too, which build their habitations without seeking the solace of companionship. The squirrel builds its little drey in the pine-tree, and the bottle-tit weaves its beautiful nest below him, without the slightest wish on the part of either to have any companion but his own mate and offspring. On the other hand, there are numberless examples of the social habit with no special constructive power. The wild dog hunts in packs; the gannet and the gull congregate around the precipitous cliffs; the tiny gnats play on twinkling wings, in clouds, under a December sun;—but there is no particular tendency to prosecute the builder's art in either.

It is difficult to understand this tendency to associate without attributing to the animals which display it something analogous to human feelings and affections. In some cases, it is true, we can trace an utilitarian end more or less obvious. It is evident that the structure of the termites could not be built without concert; the isolated beaver would be seemingly far less comfortably housed and far less efficiently protected if he had not the advantage of the dam and house, which yet he could not achieve alone; though isolated beavers, "old bachelors," are found on the European rivers. The sociable grosbeak, too, derives additional protection from the massiveness of the thatch which the united powers of the colony produce, at least we may suppose so: but what is gained, beyond the amenities of companionship, by the pensile grosbeak's choosing to hang his separate bottle-nest on the same tree and on the same twig as his fellow? The pack of wild hounds may run down a stronger and a swifter prey than a single dog could master; but what of material prosperity does the little winter-gnat gain by dancing in company with a thousand more, which it would lose if it had chosen to frisk alone a dozen yards off, in the same air and under the same sunbeam?

Surely there must be a consciousness of pleasure derived from the recognized proximity of others of the same kind, quite independent of the mere material welfare of the individual; and if this inference be unavoidable, then we must admit, even in creatures so far removed from man as these tiny invertebrata, the implantation of sentiments and feelings of like nature to those which in him we distinguish as moral,—differing not in kind, but only in degree.

There is a not unnatural reluctance in our minds to admit the existence of such feelings in the more minute creatures, even when we have no hesitation in attributing them to the dog, the horse, or the elephant. It does certainly strike one as more wonderful to find mental and moral emotions associated with a tiny insect-body and a homogangliate system of nerves; but we may discover even in such a combination new proofs of the infinite resources of the unbounded God, to whom nothing is great, nothing small. "If," says Basil of Cæsarea, "we speak of a fly, or a gnat, or a bee, our discourse must demonstrate the power of His hand who created it. The skill of the artificer is most manifest in His most minute works; and He who stretched out the heavens and excavated the seas, is the same Being who has perforated the sting of the bee as a passage for its venom."

The class of animals of which I am treating in this series of papers is composed of individuals which are far more minute than even the smallest of those which we have just been noticing. Not one of them is large enough to be detected by the unassisted human sight; or, if there is an exception, in strict literal truth, to such a statement, it only amounts to this, that when held up in the most favourable position to the light, the skilled and disciplined eye might just discern a speck of matter which microscopic examination would prove to be a *Stephanoceros*. Can it be within the range of possibility that instincts and faculties kindred in character to those above described exist in an atom of life, several hundreds of which, if ranked side by side, would comfortably pack within the inch-measure of an ivory scale? Can mental or moral perceptions and sentiments find their seat in such a being as this? Yes, there is good reason to conclude that they may. Absurd, and even ludicrous as the assumption may appear to some minds, I shall presently adduce some curious facts, which as conclusively testify to thought and feeling in the soul (ψυχή, *anima*) of a Rotifer unappreciable to the human sense, as do the social and constructive instincts in that of a grosbeak or a beaver.

Let us now consider another family of this class Rotifera. We may distinguish them as Builder Animalcules, and, selecting a scientific family title from that genus in which the pro-

minent character is most fully developed, call them the family MELICERTADÆ. Like the Flower Animalcules, they live in tubular cases, which are formed by an exudation from the surface of their bodies, and which are moulded into shape by their movements on the foot as a pivot. In one or two instances, indeed, the enveloping case seems wanting; but, as we have seen in some of the Floscules, that this defence is occasionally evanescent, it may be that in these it is so slight as to have escaped detection. Their bodies are nearly cylindrical, abruptly attenuated to a long and slender foot, the base of which is, after early infancy, permanently attached to some fixed substance, such as the stem or leaves of water-plants. In one instance, however, the feet of many individuals are attached to each other, and thus a radiating sphere of animals is composed which swims at large. This I shall describe more particularly presently.

Thus far, the Crown Wheel and the Floscules might have been united with this family; but we now come to important differences whereby it is distinguished from those genera. We have seen that they have a disk which runs into five points, beset with long bristles, only occasionally vibratile. Our present subjects have disks which do not run into points, whose divisions are twofold and fourfold, and whose margins are uniformly clothed with short cilia, which vibrate without intermission (during expansion), with a succession of rhythmic waves whose appearance to the eye is that of an endless rotation of toothed wheels.

Their most important distinctive character, however, though not so obvious as the one just mentioned, since it requires high powers of the instrument and practised skill in the observer to make it manifest, is the form of that organ in the midst of the upper body, which has been generally called a gizzard, but which I have reasons for considering as the true mouth. To describe, so as to be intelligible, an organ so complex as this, is difficult, but with the aid of the following illustration I hope to give my readers some idea of it. Take a rather pointed apple and cut it through from the point to the base, leaving the short stalk attached to one half. Choose this half (rejecting the other), and again split it through the middle, doing it carefully, so as not to separate either from the stalk which just holds the pieces together. Pull the tips slightly apart and lay them down on their rounded surfaces, the flat sides uppermost. Now take six pins, and bending them all into an arch, lay three across each division of the semi-apple, so that they lie parallel, a little apart from each other, the points of one set just meeting the points of the other, if the two divisions be pressed together. If the pins could be slightly sunk into the face of the apple, it would be so much the better. The pins

ought to be long enough for at least half their length to project beyond the outside of the apple, and if their heads (or projecting ends) could be now embraced, each set of three, by a bow-shaped piece of wax, about as large as one of the divisions of the apple, without disturbing the arrangement already described, you would have a very fair representation of the parts of the mouth in this family.

There is, however, one element more,—the *mastax*. You must imagine (for I cannot suggest any device for really representing this, so as to retain the form for even an instant) three globules of transparent substance—really it is muscular tissue—surrounding the whole apparatus, one on each side, containing the apple, pins, and wax of that side, and the third surrounding the points;—the globules united and flowing into one at their mutual contact, but preserving the three-lobed character of their outline. Remember that, this envelope being composed of living muscle, the contained parts have the power of motion, without destroying its continuity, though slightly changing its outline.

Now, to understand the action of this curious mouth and jaws, let us further suppose the whole apparatus carefully transferred to the interior of a confectioner's show-glass, the cylindrical form of which will well enough represent one of our little friends, the Builder Animalcules. Consider the three-lobed mass suspended in the cylinder near the top, almost in the centre of the diameter, the cut faces of the apple upwards and horizontal. The top of the glass cylinder is covered with a flat piece of parchment, which expands far beyond its diameter on all sides, and whose edge is more or less cut into rounded lobes. In the middle of this sheet there is a hole or tube which leads down to the apparatus; or perhaps it may be more correct to consider the parchment as forming a wide and shallow funnel, with an abrupt tube, which opens into the muscle-mass, just over the point of union of the jaws, *i.e.*, the stem of the apple; while from the under side of the muscle-lobe that embraces the points another tube leads downward to the stomach.

Of course all this is but a rude and homely comparison; but it will probably make the whole process of the reception of food in these creatures, with the uses of the various surrounding organs, far clearer than any amount of mere technical description, however accurate, could do.

The action, then, is as follows:—The edge of the expanded disk, which I represent by the parchment funnel, is, as I have already said, crowded with vibrating cilia, which produce strong currents in the surrounding water. As the ciliary beatings are all in one direction, the impulse given to the water is circular (we may consider it such at least), and thus a whirlpool is formed, the

centre of which is the lowest part of the funnel. By this contrivance, then, there is a constant rush of water down the tube, carrying with it whatever of floating atoms it may hold in suspension. These are poured down upon the lower jaws (*rami*) at the point where they are hinged together, as represented by the stem of the semi-apple, a sort of valve in the tube shutting out whatever would be hurtful or unfit for food. They are then spread along and between the jaws—the apple-quarters,—which are vigorously opened and closed alternately, with a rapid rolling movement. Thus the points of the upper jaws (*mallei*), represented by the two sets of pins, working towards each other, bruise and pierce the *infusoria*, or the atoms of organic matter, poured along the faces, and gradually grind them down, while the result passes off by the lower tube (*œsophagus*) into the stomach for digestion.

I have dwelt the longer on this matter because the same illustration serves to explain the process and organs of the reception of food, not only in this family, but in almost all the ROTIFERA. The subject is full of difficulty and obscurity to beginners, and it was not till after years of laborious study that I myself succeeded in elucidating the details; but once mastered, a large part of the structure and economy of these little creatures is intelligible. After the action of the ciliary "wheels,"—which is sure to be the first thing that arrests the attention and wonder of the beholder, and which is in no species seen to more advantage than in those of the present family,—the movements of the mouth (or *gizzard* of the older writers) attract notice, and we wish to know the meaning of them; the form and character of the very complex organs inclosed in this curious bulb, their connexion with the surrounding parts, and the object of their almost incessant vigorous working. I may find occasion, hereafter, to show by what steps I have arrived at the conclusion that this apparently *internal* organ, the so-called *gizzard*, is a real proper mouth, and its indubitable analogy with the parts of the mouth in INSECTS. In the forms we are now considering it is so much disguised and modified that I could scarcely hope to make myself understood; but we shall come to species by-and-by in which all the parts described above are readily identified, but so altered in shape, and especially in position, that we shall see at once that they form two pairs of real jaws, very closely resembling those of a biting insect. For the present I content myself with hoping that by the aid of apple, pins, and wax, the reader will have no difficulty in forming a tolerably vivid idea of the organs as they appear in this family, and a correct notion of what are their functions, and how performed.

The family before us* comprises animals which are placed by Ehrenberg in nine genera, named *Ptygura, Œcistes, Conochilus, Megalotrocha, Lacinularia, Tubicolaria, Limnias, Melicerta,* and *Cephalosiphon.* Each of these genera, however, contains but a single species; and I am much inclined to reduce the whole nine to two. Thus, *Ptygura, Œcistes, Tubicolaria, Limnias, Melicerta,* and *Cephalosiphon* seem to me to be only so many species of one genus; while *Megalotrocha, Lacinularia,* and *Conochilus* constitute another.

To the former of these I propose to appropriate the name *Melicerta,* to the latter that of *Megalotrocha.* They may be distinguished by the circumstance that in the former the individuals are always solitary; in the latter they are (in adult age) aggregated by mutual adhesion into somewhat spherical masses composed of many animals radiating in every direction from a common central point of adhesion. These compound spheres are either free or fixed.

The genus *Melicerta,* as so enlarged, or the Tube-dwellers proper, have the front or upper part of the body capable of being turned in upon itself, and concealed with purse-like folds, and of being expanded at the pleasure of the animal into a disk, which is usually much wider than the diameter of the body. This is either flat or in the form of a very shallow funnel. Its outline may form either a simple circle, as in *M. ptygura* and *M.* (*Œcistes*) *crystallina;* two circles united at one point, as in *M.* (*Limnias*) *ceratophylli;* or four sinuous lobes, more or less developed, as in *M. cephalosiphon, M.* (*Tubicolaria*) *najas,* and *M. ringens.* In each case there is, according to Professor Huxley, a double edge to the disk; of which the subordinate one is placed on the under side, and a little within the line of the principal. The former is fringed with very minute cilia; the latter with long and strong ones, whose vibratile waves form well-marked opaque spots which ever run along the margin. In each example, even where the circle of cilia is simple and appears in some aspects to be complete, it

* As I propose to subdivide the class Rotifera in a mode differing from any as yet published, I add here the technical characters of this family.

Melicertadæ.—Animal free in infancy, attached in adult age either to some foreign fixed body or to others of its own kind; inhabiting (in most cases) a gelatinous tube which is excreted from the skin. Front expanded into a broad disk, never five-pointed, but with a tendency to form two or four rounded lobes, furnished with ordinary vibratile marginal cilia in uninterrupted series. Jaws inclosed in a three-lobed mastax, each malleus soldered to the ramus of the incus, and together forming a quadranti-globular mass. Body sub-cylindrical, abruptly attenuated to a long, transversely wrinkled foot, neither telescopic nor retractile.

is really broken at the hinder part, where the curved lines turn short upon themselves.

It is a very charming sight, especially to a tyro in microscopy, whose attention is riveted and his wonder excited by the spectacle, to behold one of these animals in full play under a good instrument. Probably, when he first sits down to his observation, he discerns nothing but an opaque or semi-opaque tube standing up like a tall chimney, a little widening upward; for the timid little tenant, alarmed by the shaking of the table produced by the observer's movements in sitting down and preparing, is shrunken down out of sight into his snug castle. In a few moments, however, something peeps from the top; perhaps it is a simple rounded mass of crystal flesh, as in *ceratophylli*; or the long antennal tube of *cephalosiphon* thrust out by jerks, and vigorously thrown to and fro; or the two incurving horns of *ringens* slowly protruding.

Suppose it is the last-named species, the most attractive of all, perhaps I may say the most interesting of the entire class of ROTIFERA. As the rounded mass of translucent flesh still protrudes, crowned by its two horns like the spines of a rose, two other organs suddenly appear, stretching out from another part of the convexity, two long clear tubes, extending horizontally, one on each side, which are the feelers or antennæ. Now a quivering is discerned in the interior; and in a moment the extremity opens and unfolds into four wide rounded flat lobes, like the petals of a transparent flower. The plane of this flower-like disk is not horizontal, but more or less oblique, sometimes approaching to perpendicular, and the two petals which are the highest are considerably larger than the two that are lowest; the former being the fore, the latter the hind pair. (See Plate XXVI., figs. *a*, *b*.)

No sooner is this lovely flower in full blossom than you perceive the curious furniture of its margin. You cannot help perceiving it; your eye is instantly drawn from every other part to gaze upon this wonderful sight. There is seen a set of black beads on the very edge, each divided by a narrow interspace from its fellows, which are engaged, without a moment's interruption, and with the most perfect regularity, in chasing each other all round the margin. Round and round they go, into the sinuosities, over the projections, with a steady majestic swiftness which is quite entrancing to behold. If you suppose the crown-wheel of a watch to be made of glass, and the teeth to be painted black, you would have in its movement an appearance somewhat like that of one of the simple disks of the genus, such as that of *crystallinus*; but in this species the case is complicated by the wheel being four-petalled instead of circular. Again, however, you see that the disk itself does not

rotate, but the black teeth only, and these change their form in certain parts of their revolution, becoming confused, and then again bursting into distinctness.

It is almost impossible to believe that you do not see an actual rotatory movement of the parts, that the black spots are not real solid organs, they are so palpable, so well-defined. Yet it is manifest on a moment's reflection, that such a motion, continued without intermission for hundreds of revolutions, would be perfectly incompatible with the necessary conditions of an animal body. In reality you do not see parts at all; the black spots are only waves in the cilia: an optical illusion produced by the cilia being brought momentarily closer together at certain regular points, causing opacity, and alternating with correspondent separations, causing transparency. These *waves* run ceaselessly round, but the cilia themselves do not change their place: they merely bend and straighten themselves in rhythmic alternation.

After we have somewhat satiated our sense of sight with this beautiful spectacle, we have leisure to look at the tubular case in which the animal dwells. It is not, like that of the Crown-wheel and the Floscules, and, indeed, like those of most of the species of this family, transparent and simply gelatinous, but quite opaque; so that, with the exception of those upper parts that are protruded from its protection, the body is altogether concealed. We can discern that its surface is composed of round bead-like objects set in a regular symmetry in a kind of mosaic pattern, and that these globules are of a dark-reddish or yellowish-brown hue. In truth, the foundation of this *Melicerta's* case is a tubular layer of gelatinous mucus, thrown off from the surface of its body, tenacious and transparent, as in other kindred cases, as may be distinctly seen in the creature's infancy, when it begins to construct its house; but there is superadded to this an outer layer of stiff globules, which are imbedded individually in the gelatinous substance, imparting to it firmness and opacity. The preparation and deposition of these building-stones form one of the most interesting chapters in the history of the class.

In carefully watching your specimen, it may be that you will be fortunate enough to detect him in the very act of building his house,—a process which is not performed all at once, but step by step, at long intervals, a little at a time, as the owner's growth requires commensurate elbow-room. Now, as he is the judge of this necessity for labour, we cannot force him to work when he has not a mind to it; and so you may watch a number of individuals, and tantalizingly fail in ever seeing the process. But it may be that you will be more fortunate, as I have been

repeatedly. Lest, however, you be unsuccessful, I must describe to you what takes place.

If you get a sight of the animal, while fully expanded and rotating, *sidewise* (as shown in fig. *b*), you will see that the front outline of the head descends from the sinus between the great upper petals, and follows an irregular curve to a rounded projection which I have familiarly called the chin. Below this there is a considerable recess, at the bottom of which we may discern a tiny cup-like cavity, midway between the two antennæ. I have indicated it (in fig. *b*) as seen through the transparency of the flesh, which projects a little on each side of it.

Carefully marking now the course of the great ciliary wave on the margin of the petals, you will observe a certain deviation from its circular course. But this will be made much clearer by an ingenious device, which will afford you pleasure on several accounts. Rub a cake of water-colour carmine on a palette, and with a sable pencil take up a minute portion, and diffuse it in the water of your animalcule cell, which contains your *Melicerta*. Put on the glass cover, and observe again. As soon as the little animal recommences its ciliary gyrations, the dark-red atoms of pigment are put in motion, and you see at once that you have obtained a very important aid in distinguishing the currents. If you have not diffused too much paint, the animal will continue its rotations without inconvenience, and the transparency of the water will not be materially affected. The result is immediate and striking. Particles of red pigment are drawn from all quarters toward the disk, on approaching which they arrange themselves in a wide band, which is hurled along in directions parallel to the sinuations of the margin, keeping a uniform distance just outside the ever-chasing black wave-specks. This band of red dots circles ceaselessly round and round, but at the great frontal sinus a portion of them is ever drawn off from the general course, and driven along the irregular front line, which you see in the side view (fig. *b*), toward the projecting chin. The cloud of dots rapidly runs on round the tip of this organ, rushes under it, still following the outline, till it terminates in the tiny cup beneath, which I have already mentioned. In order now to pursue the observation with advantage, we must get a sight of the animal in front, so as to have a direct view of the little cup. This would be by no means a chance scarcely to be hoped for, for while the *Melicerta* is engaged in building she very frequently turns herself from side to side, so as to bring different aspects of her person before the eye. Having obtained such an aspect, you see that the interior of the little cup is beset with very minute cilia, which maintain a rapid rotation. The frontal current,

then, drawing off through the great sinus a portion of the circling cloud of pigment, deposits it atom after atom in the little cup-shaped receptacle until it is full. Meanwhile the accumulating contents have been, and are still, whirled round and round within the cup by the action of the interior cilia, which process, probably aided by the secretion and admixture of some animal glue, gradually consolidates them into a tiny globular pellet, whose shape is moulded by that of the cup. Suddenly now we see the animal bend itself forward till the cup is brought into contact with the upper edge of the case; it remains so bent for an instant, and then as quickly resumes its upright posture. *The cup, however, is now empty;* for the consolidated pellet, a little globule exactly agreeing in shape and size with those of which the case is made up, but differing from them in being of a deeper hue, *has been left on the edge of the case,* where it firmly adheres. The process under these circumstances occupies from two and a half to three and a half minutes; at the end of which interval another pellet is completed and instantly deposited. So the work goes on; the animal occasionally shifting partly round, depositing two or three at one spot, then a few at another part of the edge, not proceeding regularly along the horizontal course, so that the unfinished edge of a case is always uneven; while yet, on the whole, the edifice heightens with pretty fair equality. The profusion of solid matter in suspension, available for the animal's purpose, causes the process of manufacturing these bricks to be much more rapid than it would be under ordinary circumstances. The material commonly collected appears to be the organic matters which form the residua of digestion, with which their colour well agrees; and these are doubtless obtainable only at intervals and in small quantities.

Thus we have here an animal of invisible minuteness which displays more than merely constructive powers. It had been surely a most interesting phenomenon if the tiny creature had formed its case, like the caddis-worm of our brooks, out of ready-made materials which it picked up and appropriated, and no more. But, in addition to this, there is the instinct of fashioning the crude materials into solidity and shape,—a true manufacturing process. Here is not only a clever architect and bricklayer who builds his symmetrical house, brick by brick in regular courses, cementing each with a mortar which, like the Aberthaw lime, sets and hardens under water; but an artisan who collects various sorts of crude substances, and, with the aid of certain machinery peculiar to himself, consolidates, compresses, and moulds them into bricks of regular form and perfectly uniform dimensions, before he makes use of them.

I will take the liberty of repeating here some reflections,

which I have made in another place, on the psychical phenomena legitimately inferrible from this minute animal's proceedings :—

"It is impossible to witness the constructive operations of the *Melicerta* without being convinced that it possesses mental faculties,—at least if we allow these to any animals below man. If, when the chimpanzee weaves together the branches of a tree to make himself a bed; when the beaver, in concert with his fellows, gnaws down the birch saplings, and collects clay to form a dam; when the martin brings together pellets of mud and arranges them under our eaves into a hollow receptacle for her eggs and young, —we do not hesitate to recognize *mind*—call it instinct or reason, or a combination of both,—how can we fail to see that in the operations of the invisible animalcule there are the workings of an immaterial principle? There must be a power to judge of the condition of its case, of the height to which it must be carried, of the time when this must be done; a will to commence and to go on, a will to leave off (for the ciliary current is entirely under control); a consciousness of the readiness of the pellet, an accurate estimate of the spot where it needs to be deposited (may I not say also a memory where the previous ones had been laid, since the deposition does not go on in *regular* succession, but here and there, yet so as to keep the edge tolerably uniform in height?), and a will to determine that there it shall be put. But, surely, these are mental powers. Yet mind animating an atom so small that your eyes strained to the utmost can only just discern the speck in the most favourable circumstances, as when you hold the glass which contains it between your eye and the light, so that the ray shall illumine the tiny form while the background is dark behind it!"

This prettly little builder is very common on most of our pond-weeds, and when it does occur, a good many are generally found in close proximity.* I have had them swarming to such a degree that sixty or seventy were crowded on a single small leaf. An adult will measure 1-20th of an inch in height, of which the case may be 1-24th of an inch. Such a case contains about thirty or thirty-five horizontal rows or courses of pellets. Each pellet is surrounded by six others; they are set in uninterrupted perpendicular lines; but those of one horizontal row are made to alternate with those above and below it, just as bricks are ordinarily set in a wall. Each naturally-made pellet, exa-

* Dr. Mantell ("Thoughts on Animalcules," pl. iv.) has figured an adult *M. ceratophylli*, with seven young, each with a well-formed case, adhering to various points of the parental case. I have never met with such an example as this, but have seen one case attached to an older one.

mined separately, is of a yellowish or olive colour, composed of granules. Old cases have their surface studded with minute parasites, both plants and animals, as *Confervæ*, *Diatomaceæ*, *Podophryæ*, and other extraneous matters, even to the summit. By picking the case to pieces with the points of needles under a low-powered dissecting microscope, I have been enabled easily to extract the animal; it is often hurt by the process, but generally it is sufficiently whole to display the internal organization, which, owing to the opacity of the case, cannot otherwise be discerned. It exhibits no peculiarity, however, that calls for notice here.

The eggs are laid within the case, as I have described and figured in the Floscules (*vide supra*, p. 166, Plate IX.); nor do they importantly differ from those of that genus, except in their shape, exhibiting a longer ellipse. This lengthened form appears to be characteristic of *Melicerta* (at least I have found it in all the species whose eggs I have examined), and to be peculiar to it.

On certain occasions I have, however, found eggs of a very different figure and appearance, which I have reason to believe would have produced male animals, probably of peculiar form. On these eggs, and on the development of the young, I have communicated some observations to the Microscopical Society, which may be of sufficient interest to be repeated here.

Opening one or two cases of *Melicerta ringens*, I freed one and another very curious egg-like bodies, not symmetrical in shape, being much more gibbous on one side than the opposite, and measuring 1-150th by 1-260th of an inch. Each was encircled by five or six raised ribs, running parallel to each other longitudinally, somewhat like the ribs (*varices*) that adorn the beautiful shells known as wentle-traps. Viewed perpendicularly to the ribs, the form is symmetrical—a long, narrow oval. The whole surface between the ribs appeared punctured or granulate, and the colour was a dull brownish yellow. Under pressure this egg was ruptured, and discharged an infinity of atoms of an excessive minuteness, but every one of which, for a few seconds, displayed spontaneous motion. Their whole appearance, and the manner in which they presently turned to motionless disks, were exactly the same as of the *spermatozoa*, which the male eggs of other ROTIFERA contain, except that these were more minute than usual.

From another case I extracted an egg of the ordinary form and appearance. It was very long in proportion to its width, measuring 1-145th by 1-390th of an inch. The contained embryo was well advanced; two red eyes were plainly seen, both by reflected and by transmitted light; the mouth (*mastax*) was transverse, very large in proportion, and the jaws worked

vigorously; a little opaque body, white under sunlight, was in the posterior part. This embryo died without being hatched.

I found a young one, about half-adult size, attached by the base of its tube to the side of the tube of an adult, near the summit of the latter, so as to project obliquely upward. This specimen, which was perfectly formed, gave me an excellent opportunity for observing the ventral aspect and the dorsal. It had two red eyes, one placed near the base of each larger petal. I have never discerned the eyes in adults. It was very energetic, diligently engaged in manufacturing the pellets and laying them on. It seems that the action of the pellet-cup is voluntary, and not always coexistent with the passing of the ciliary current over the chin. The animal frequently makes abortive efforts to deposit a pellet, and sometimes bends forcibly forward to the edge of the case before the pellet is half formed.

This specimen lived with me fourteen days after I discovered it, active and apparently healthy, till it suddenly died. During the whole time it scarcely increased in size, nor did it add any pellets to its case, except a few in the first day or two. The eyes remained distinctly visible to the last. It would be interesting to know the natural period of life in these little creatures.

On another occasion, looking into the animalcule-cage, in which were several cases, I found a young one swimming rapidly out in a giddy, headlong manner. I believe it was just hatched. Its form was somewhat trumpet-shaped, or like that of a *Stentor*, with a wreath of cilia around the head, interrupted at two opposite points. The central portion of the head rose into a low cone. After whirling about for a few minutes, its motion became retarded, and it began to adhere momentarily, and to move forward by successive jerks, not more than its own length at once. The period of its remaining stationary increased, so that I several times supposed it had taken permanent position, when some shock or alarm would send it off for a little distance again. At length, about an hour after I first saw it, it finally settled, adhering by the foot to the lower glass of the box. After a few rapid gyrations upon the foot as a pivot, it became vertical. The form of the adult was now distinctly assumed; the four petals of the disk were well made out, though the sinuosities were yet shallow: the antennæ at first were only small square nipples, but soon shot out into the usual form; the ciliated chin was distinct, as was also the whirling of the pellet-cup immediately beneath it. A pellet was quickly formed, and instantly deposited at the foot — the first brick of its house; the same operation was repeated with energy and

industry, so that in a few minutes a row of pellets was seen, forming a portion of a circle around its foot-base. When two or three rows were formed, I took occasion to measure the time of their construction: one pellet was deposited every minute with great regularity. I mixed a little carmine with the water: the result was beautiful; for the dark torrent that poured off in front, and the appearance of a rich crimson pellet in the cup, were instantaneous. Yet the imbibition seemed deleterious; for the animal would withdraw itself suddenly, after a revolution or two, and presently retired sullenly, having laid five or six carmine pellets, whose deep tints made them conspicuous on the pellucid yellowish ones. Some three hours after, I saw that no more had been laid. But in the course of the night the case was considerably increased with carmine; the part so made was much less regularly formed of pellets than that composed of the natural material; for the red portion was all confused and blended, as it were, into a mass, without distinction of pellets, though retaining the tubular form.

A large one, whose case had become accidentally injured near the base, so as to be slit for some distance up, protruded itself through the opening, remaining still attached by the foot. It did not enter again, but continued for several days, carrying on all the functions in the healthiest manner, exposed. It frequently made pellets, but these were never deposited, but allowed to wash off into the water; nor was any attempt made to construct a new case. A half-grown one, very active, that was near, deposited pellets only rarely,—eight or ten in several days; whence it appears that this process is quite voluntary; indeed, if it were not so, so rapid is the formation, that the tube would be increased beyond all bounds in a very brief period of the animal's life.

Of the other species of this genus I shall not here say much. *M. ceratophylli* (see fig. *c*) inhabits a case which is more or less of a yellowish-brown tint, but is sufficiently translucent to allow the body and foot of the animal to be discerned through it, and is never strengthened with anything corresponding to its sister's ingenious outer wall of self-made bricks. It has not attained to that effort of *mind;* perhaps I might say, it has not sufficient *head-piece;* for if you look at its coronal disk, you will see that it is only half as much developed as its sister's; for, whereas that has four petal-like lobes, this has but two. These two form perfect circles united at the central point of contact; or the whole outline may be designated a figure of 8. From its symmetry it is a very elegant object, especially when the ciliary waves are rotating. The gelatinous case in this species is generally much beset with

Diatomaceæ, *Confervæ*, &c., which are entangled in the viscid substance.*

M. najas I have never met with. Ehrenberg describes it as having a disk divided into two lobes, each of which is slightly indented, so that it is four-petaled, but less distinctly than in *M. ringens*. In other respects it seems to present no peculiarity worth notice.

M. cephalosiphon has a disk of much the same form, the sinuous indentations being even less marked. This has lately been discovered near London in abundance on the leaves of the *Anacharis alsinastrum*,—that recently-introduced ditch-weed, which is fast usurping the place of all other aquatics in our ponds and rivers. Mr. Slack, in his "Marvels of Pond Life," p. 149, first figured it, and has since, by supplying me with specimens, kindly enabled me to describe it more fully.† The species dwells in a tall but narrow case, of so dark brown a colour as to be quite opaque. Its texture is coarse and rough, but it is not made up of well-fixed symmetrical pellets, as is that of *M. ringens*. The most remarkable peculiarity of the species is a single antenna (each of the preceding species has a pair of these organs), which is of great length, forming a transparent tube, furnished at the tip with a tuft of diverging bristles. This organ is evidently used as a feeler; and it is highly interesting to see, when the animal is emerging from its case, how this long antenna is thrust out first, and is jerked with great vigour and suddenness from side to side, poking here and there, as if to ascertain that the coast is clear for the disk to be protruded and to commence its ciliary operations with security against danger or interruption.

M. crystallinus, if I may judge from my own observations, and I have seen it in great numbers, does not deserve the specific name which Ehrenberg applied to it. He describes the translucency of the case to be such as to render it difficult of detection. Possibly he met with only youthful specimens; for I find, on the contrary, that it is very dark, and so nearly opaque that the animal can scarcely be seen through it, at least in old individuals. The disk forms a simple circle. Though a beautiful creature, there is little in its economy sufficiently special to call for further remark.

The last species, *M. ptygura*, if I rightly identify it, is somewhat peculiar, and seems to approach in its form to the following genus. In October, 1849, I found two specimens of a fine wheel-animal which I could not satisfactorily identify with any

* I have given the history of this species in detail, with figures, in my "Evenings at the Microscope," pp. 302–310.

† In the "Intellectual Observer," for Feb. 1862, p. 49.

of Ehrenberg's descriptions, and which I therefore named, as a new species, *Megalotrocha velata*. I have, however, had reason since to think it was his *Ptygura melicerta* (see fig. *d*). The animal was not contained in any case, that I could discern, nor was it attached to any others of its kind; but the observations were insufficient to determine absolutely that these conditions were permanent. It laid a large egg in my possession, and actually under my eye, so that it was in adult age. On the other hand, it displayed two distinct eyes,—in general, a mark of youth in this family. Its general figure was somewhat trumpet-shaped, slightly swelling in the middle. The disk was very large, forming a continuous nearly circular outline, and partially surrounded by a layer of granular tissue. The foot terminated in an adhering sucker, whose figure resembled that of a glass stopper in a phial; the dilated extremity of this was capable of adhering to any foreign substance.

I come now to speak of the three species, which I propose to unite into the one genus, *Megalotrocha*. They have a disk remarkable (as the name signifies) for its great size; it forms a very broad circular or ovate figure, notched at one point. To be more precise, the course of the cilia is continuous all round, with the exception of the middle of the ventral side, where there is an abrupt indentation or sinuosity. But their most remarkable peculiarity is their social habit: they voluntarily seek the society of others of their own species at a certain age, before which they have been free and solitary, and then adhere together by the mutual contact of the bases of their feet, so that they project in a radiating manner on all sides from a common centre, thus constituting compound spheres, which sometimes swim at large on a roving commission, and in other cases are permanently anchored to some aquatic plant. I suspect in all cases (though Ehrenberg says it is not so in *M. albo-flavicans*) that there is secreted a common gelatinous envelope, corresponding to the isolated cases of the *Melicertæ*, but so agglutinated together by the proximity of the animals, and by the viscous nature of the substance, that a common ball of jelly is formed, pierced with cells in which the creatures dwell, each in its own.

My own personal acquaintance with this form is confined to *M.* (*Conochilus*) *volvox*, of which I found many clustered spheres, some years ago, in one of the tiny pools on Hampstead Heath (see fig. *e*). The appearance of these—from their form, their colour, and their association, and their majestic rolling movements—was very interesting.

The clusters are very distinctly visible to the naked eye, swimming slowly along, ascending or descending, by the motion of the powerful cilia that surround the head. Each cluster

consists of many individuals (I examined one of seventy) united by the extremity of the foot, and radiating from a common centre in every direction. The heads of all point outward, and the ciliary currents of all give the spherical clusters a slowly-revolving motion as they swim. An inexperienced observer might for a moment suppose that he had a group of large *Vorticellæ* before him, but the complexity of their organization soon shows the difference between them. This species displays the existence of muscles with remarkable distinctness, several of which run down longitudinally, and others go round the body transversely. The shape of each animalcule resembles that of a bell wine-glass when fully extended, of which the body is represented by the vessel and the foot by the stand; the latter, however, tapers to a blunt point, without any apparent division or expansion. The whole outline is constricted with transverse corrugations, and is capable, especially the foot, of forcible contraction in length. The frontal disk is large, and divided into two semicircular portions, round which the cilia seem to be set; yet, when they are in active rotation, the eye cannot discern any break in the ciliary crown. The centre of the front rises into a blunt cone, on one side of which projects a little jointed antenna, bearing a bristle at its tip. Ehrenberg describes four conical papillæ, all of which are sometimes bristle-tipped, but more commonly only the front pair. I, however, could detect but *one*.* The position of this organ, within the ciliary crown, is remarkable; its ordinary place being outside, that is, below its plane, as seen in *Melicerta*.

Two very minute eye-specks are seen, rather wide apart; and below is the gizzard-like mouth containing two hemispherical jaws, set with teeth. The viscera are pale yellow, and the jaws are orange-red; else the whole animal is colourless and very transparent. When a cluster is taken out of the phial in which it is swimming about, and put into the live-box, the number of animals lying over each other, if it be populous, is confusing. The numerous feet radiating from the centre like the spokes of a glassy wheel, and the multitude of crystal bells around the circumference—each surrounded by its crown of rapidly-rotating and strongly marked cilia, are almost distracting. Some display the front, some the side; some turn themselves so as to present to the eye a transverse view of the crown, others are almost vertical; it is only in the latter, when the eye looks down upon the disk, that the divided structure can be seen. Some are continually shrinking up by forcible contractions of the foot;

* From this discrepancy, and also from the silence of Ehrenberg respecting the very peculiar form of the egg (to be noticed presently), there is a possibility that mine may have been a distinct species from his.

and some are vomiting forth the flattened pale-yellow eggs which are ready in the ovary. This is, indeed, the first thing done as soon as a cluster is put into the live-box; the animals being probably excited by being caught and moved from vessel to vessel. Many eggs are presently seen, forcibly expelled from different individuals and whirling about in front of the animals. (See figs. *f, f, f.*) Ehrenberg says, that in *M. albo-flavicans* they are attached to the parent by a thread for some time; but in this case there is certainly no attachment: they are simply retained by the vortices of the ciliary currents. This was clearly shown in the case of one egg, which, on being ejected, for some cause or other, escaped being caught in the ciliary currents, and swam slowly away, with the original impulse, far out of the range of the parent. I did not trace the development of any of the eggs.

The form of the egg is very peculiar: it appears to be nearly circular, flattened on one side and convex on the other; there is considerable difference in their size; they are of a pale-yellow hue, marked with several blackish specks.

After having been some time, perhaps two or three hours, in the live-box, the animals begin, one by one, to separate themselves from the group, and to swim off in freedom. The foot, immediately after separation, shrinks up so as to be little more than a thick nipple, and sometimes shrinks completely within the body, within which it is seen much shortened and corrugated; the body is also enlarged and turgid at the bottom. The ciliary motion now carries it rapidly along, revolving on its longitudinal axis, until it is brought to the margin of the box or to the edge of the flattened drop of water, along which it then swims in a backward direction, the foot foremost; now and then it rapidly reverses its course, but invariably turns so as to keep the foot before. After pursuing this amusement a little while, it stops, becomes still; the action of the cilia grows feeble and languid: these organs hang over the side of the coronal circle like flexible hooks; the jaws cease to work, and the creature soon dissolves into a yellowish indistinct mass. I tried to feed them with indigo, sap-green, and carmine; but though the pigment, after being whirled around the ciliary currents, accumulated in masses outside the cone, I could not perceive that a particle entered the body of any.

The largest cluster that I examined, measured, when under the pressure of a compressor, about 1-30th of an inch in diameter, and the longest extended animal 1-50th. When the pressure was removed, these measurements were reduced respectively to 1-36th and 1-70th. An animal contracted in swimming independently was about 1-150th of an inch long.

Professor Huxley has given a valuable account of the struc-

ture and economy of *M.* (*Lacinularia*) *socialis*.* He finds the clusters of this species abundantly studding the leaves of *Ceratophyllum*, which grows in the Medway, near Farleigh Bridge. In general appearance and habits this species agrees with the one I have just described; the animals, however, are more slender, and the distinction between the body and the foot is less strongly marked. The eggs are of the ordinary form, not of the remarkable turban-like shape of those of *M. volvox;* they are laid in the cells of the gelatinous sphere, where they are hatched. Here the young live for a while; but as soon as the disk begins to assume a triangular outline, and the foot to be developed, they "begin to 'swarm,' uniting themselves by their caudal extremities, and are readily pressed out as united free-swimming colonies, resembling, in this state," the previous species. Ehrenberg says that seven or eight eggs are deposited in each cell; that these form a new cluster, swim away, and form an envelope of their own, but that, when only one is born, it attaches itself to the side of its parent. We may inquire how the young clusters of six or seven (and the young of one parent accumulated in the case at one time could never greatly exceed this number) increase to forty or more. Perhaps this last fact may help to guide our conjectures. Probably, as the individual young grow in size, the interspaces left between them, becoming wider, afford ample room for intruders; and the new progeny of these, as they are hatched, at once take their place, one by one, in the parent sphere, swelling its bulk up to the dimensions of maturity; and that the swarming does not begin to occur till these dimensions are attained. The free-swimming swarms are temporarily in the condition which in *M. volvox* is permanent, and may readily be supposed (as has, indeed, been done) to constitute a distinct species. As the Berlin Professor observes, "They have not yet the character of the genus [species], but are *Lacinulariæ* notwithstanding, as young frogs without feet, and with gills and tails, must still remain frogs."

Professor Huxley has discovered that another form of eggs, which he compares with the *ephippial* eggs of some of the water-fleas (*Daphnia*, &c.), is produced by *M. socialis*. They are inclosed in a double investing membrane, the inner of which sends off a partition that divides the contents into two equal portions. Cohn, however, believes that these are not proper eggs, but *gemmæ*, having analogy to the buds of a plant, while eggs are analogous to its seeds. New plants may be grown from either; but, physiologically, the plant produced from a bud or cutting is only a severed and independent part of the

* "Trans. Micr. Soc," 1853.

individual life of the stock; but that produced from a seed is a new plant, a new generation.

Experience shows that this, like the former species, cannot long survive confinement. I have already mentioned the fate of *M. volvox* in my possession; Ehrenberg says of *socialis*: "In vessels of water they rarely support themselves eight days; they die and fall to the bottom, even if plants be growing in them."

EXPLANATION OF THE ILLUSTRATIONS.

Plate X. represents a shoot of *Nitella* with stationary *Melicertadæ* adhering to it, and a free cluster of *Megalotrocha*.

Fig. *a*. *Melicerta ringens*, viewed from behind.

b. The same, viewed from the side.

c. *Melicerta ceratophylli*, viewed from behind; with two eggs in its case, attached to the foot.

d. *Melicerta ptygura* (?) viewed from the side.

e. A large cluster of *Megalotrocha volvox*, freely rotating and swimming. Some are viewed vertically, some from the front, some from the side, and a few are closed.

f. Eggs of the same, held in the ciliary vortex, and seen in various positions.

The whole magnified about 350 diameters. All the figures taken from the life.

THE COMMON TRUFFLE (TUBER CIBARIUM).

BY JABEZ HOGG, F.L.S., M.R.C.S., ETC.

IT is, perhaps, not very generally known, that the curiously formed, irregular-looking mass, so much esteemed for its delicious taste, and sought after as a luxury, the truffle, is in truth a species of mushroom, more properly speaking, a subterranean puff-ball, or fungus.

The common truffle, *Tuber cibarium; Licoperdon Tuber* of Linnæus, and described by Pliny under the name of *Tubera sincera*, appears to have been well known to the ancients. The truffle of our markets occurs in rounded nodules, varying in size from a nut to that of a large potato, irregular in form, with a rough warty-looking black outer coat. It grows a few inches below the surface of the ground in several parts of England, Covent-garden Market receiving its supply from the downs of Wiltshire, Hampshire, and Kent, as well as France and Germany. Its existence, entirely removed from the action of light, is an anomaly even among plants of the fungus kind; for light, although not in a large degree necessary even to the fungus, is almost always indispensable to its full development. It would, therefore, be most difficult to discover, if it were not for a peculiar and penetrating odour, which dogs are taught to recognize; and by the aid of these useful animals its presence is detected hidden beneath the soil. Pigs are very fond of them; and in Italy advantage is taken of their instinctive knowledge of the spots, and natural propensity to dig them up, to gather a larger supply.

France produces three excellent varieties, the *truffe de Perigord*, with black flesh; the *truffe de Bourgogne*, with white flesh; and a third with violet flesh. The first is much esteemed, on account of its odour and tenderness, and from it is made a finer seasoning or flavouring ingredient for the luxuries of the table.

Riègel, with the desire of discovering the peculiar chemical principle which gives odour and flavour to the truffle, carefully analyzed the Perigord variety, and found it consisted of a brown fatty oil, with traces of a volatile oil, an acrid resin, osmazone, mushroom sugar, nitrogenous matter insoluble in alcohol,

prussic acid, phosphoric acid, potash, ammonia, albumen, pectine, and vegetable mucus, with fungic skeleton. So that the odour is chiefly due to a peculiar yellow empyreumatic oil, not unlike spirit of *hartshorn*. M. Vittadini, of Milan, was among the first to make a more careful examination of the truffle, both of its external and microscopical characteristics, and succeeded in throwing a considerable amount of light on its organization. His observations have been much extended by the researches of the Rev. M. J. Berkeley, Klotsch, Corda, and the Tulasne's. Vittadini pointed out that these fungi presented two essentially different types. In the one, *Hymenogastreæ*, the internal fleshy mass presents a number of winding cavities, lined by a membrane analogous to that which clothes the gills of the Agaric, and the superficial cells produce at their free extremities three or four spores, or seeds, which become detached, and eventually fill up the cavities.

The other type, *Elaphemycæ*, *Tuberaceæ*, comprising those of the truffle kind, and as may be surmised by the scientific name assigned to them—*Tuber cibarium*,—are plants characterized from the underground root presenting a fleshy mass, the outer surface of which constitutes the common envelope, or skin, termed the *peridium*, while the numerous narrow sinuous cavities are lined and in part filled up by filamentous tissue, mingled with cells of a peculiar form, and terminating in spores.

To place the truffle among the class *Tuberaceæ* would appear to be a mistake; for it can hardly be said that this curious underground esculent, a perfect plant destitute of leaves, stems, and roots, in any way resembles the genus *Tuberaceæ*, except in one unimportant particular, namely, external appearance. Every cell in the truffle is an assimilating surface; the whole plant is a reproductive organ; and every part of the structure performs the functions which, in the more complex plants of the *Tuberaceæ*, are performed by organs specially set apart.

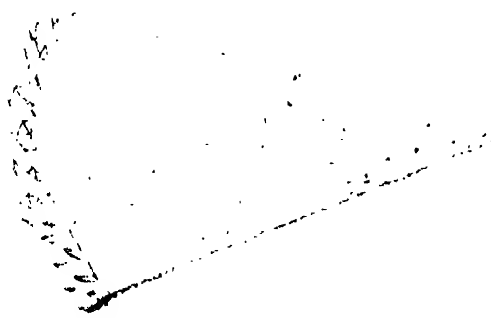
The fungus genus, which claims the truffle, until very recently furnished us with but few varieties; the more careful researches of the Messrs. Tulasne made throughout France, enabled them to extend a before limited list to a hundred and forty-four species, comprehended in twenty-five genera of these plants.

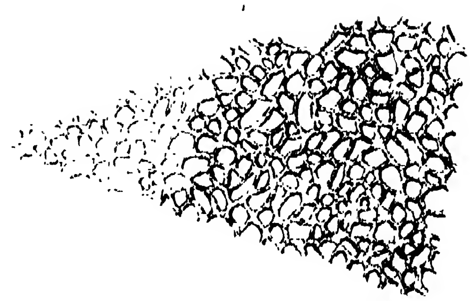
The whole family of fungi are developed from minute spores or seeds, which are continually carried about by currents of air. At length the seeds are deposited on a suitable soil: their growth is most rapid; when once rooted, they are extremely tenacious of life, and exhibit considerable powers of resisting frost, as well as heat; some seeds having been subjected to the boiling heat of water without losing their power of germination.

Truffles prefer a dry, light, calcareous soil, in woody grounds,

and are found growing throughout the whole of Europe, India, Africa, and New Zealand. "In some parts of France, as in Poitou," says Berkeley, "it is simply necessary, in order to their supply, to inclose a spot on the chalky downs, sowing it with acorns. As soon as the saplings attain a growth of a few years, the truffles appear, and a harvest is obtained for many years successively without further trouble." Thus it appears that the culture of truffles is reduced to as simple a process as that of most plants; but the apparent necessity of first planting acorns has given rise to much misapprehension on this head; for, in a French journal of science last year, a paper appeared, written with the avowed object of "*clearing up the mystery which has so long surrounded the reproduction and* ARTIFICIAL PROPAGATION *of the truffle*," which, the writer says, "is simply an underground species of *oak-apple*, produced by an insect on the rootlets instead of the leaves of the oak. The white oak is chiefly selected, and the young trees should be planted in a light porous soil,—a sandy or chalky soil is the best, so that the *flies may find ready access to the roots.* A southern aspect, with plenty of sun and air, is the preferable situation both for trees and flies. There are as many varieties of these special flies as of truffles. They are mostly of a small size, and make their appearance after rain has fallen, and during the warm months of July. In August and September they penetrate to the roots of the trees for the purpose of depositing their eggs. After the small puncture has been made by the fly, this portion of root separates from the parent tree, and goes on increasing in the same way as the oak-apple, and in process of time becomes food for the larvæ; which are hatched about March. Then commences the work of destruction, as the larvæ eat their way out of their winter prison, and pass through the usual metamorphoses to that of the perfect fly." The paper concludes as follows: "that by a careful application of the foregoing knowledge large plantations in the department of Vaucluse have been for a long period very profitable to their owner, A. W. Falon; and by digging up the roots with the chrysalides at the proper time, they have been transported in boxes to form other plantations equally profitable."

The microscope clears up all this ingeniously woven tale, and we read by its aid the life history of this remarkable underground plant; and although so extremely simple in its organization, we see in it the secret manner in which nature builds up her most complicated vegetable structures. A section from the fleshy-looking mass cut very thin, and viewed under a power of 250 diameters, is found to be chiefly composed of cellular substance, the interspaces of which are filled up by jointed filaments, homologous to the mycelium or spawn of other fungi,





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—in the mushroom, as an example, it is the mushroom spawn, —while the veins, the reproductive parts, contain in their cellular tissue minute oval capsules, with two or more globular yellowish seeds ; this curious structure having all the parts of nutrition and reproduction inclosed internally, instead of externally, as in other fungi. Plate XXVII., fig. 4, exhibits this last-named structural peculiarity; figure 3, the outer or cortical coat ; and figures 1 and 2, sections of small truffles, natural size.

In language somewhat more precise and scientific, we should say truffles are produced in this way ; the mycelium quickly decays and allows the fungoid body to grow on in an isolated condition. About September the ground becomes covered with numerous white cylindrical, articulated filaments, not visible singly to the unassisted eye, but by their immense numbers and rapid growth readily seen, and found traversing the soil in every direction. These white flaxen threads are continuous with other flocculent filaments of the same nature. In the young truffles the external layer is gradually consolidated, and in a short time the destruction of the flocculent filaments complete and lost in the young plant, which is soon isolated in the soil, and then the outer or cortical coat hardens, and ultimately has the appearance of a small nut. Thus, like other fungi, truffles are reproduced by spores, which give origin to filamentous mycelium and seed-vessels, the source of numerous offspring. Groups of spores are pretty objects; their stellate appearance reminds one of the Xanthidiæ; the mass of the full-grown plant at particular seasons is almost wholly made up of these bodies, the yellowish-brown coloured seeds. The observations of M. Vittadini had already indicated the curious arrangement of the black and white veins, which traverse the tissue of the truffle; and the more careful investigations of the Messrs. Tulasne have clearly shown their relations and destination.

The young truffle exhibits very irregular sinuous cavities, partly communicating with each other, and terminating sometimes at a single orifice corresponding to a depression on the outside. As they grow older, the partitions which separate the cavities become thickened, and the tissue comprising their surfaces is developed into a kind of longish soft hair,—tomentum, which obliterates them : hence result the two systems of veins; the one set coloured, corresponding to the partitions which separated the primitive cavities, the other white, forming the filamentous tissue, and filling up these cavities. The former are continuous with the external cortical layer or outer skin ; while quite internally they are made up of a network of filaments or elongated cells (see fig. 4), running in the direction of the cavities ; from this shorter filaments branch off, almost perpendicular to the first, and in the dilated extremities of these

are developed the seeds,—sporangia: the deep colour of the mass is owing to the brownish yellow of these seeds. The other set of white veins appear to be formed of the unproductive sterile filaments, originating like the former primitive partitions; but these veins or filaments being filled with air, present a dull white appearance when thin slices are examined by transmitted light.

In these plants, therefore, we have a double system of veins or laminated filaments; one set arising from the cortical tissue absorbing the surrounding moisture and serving to transmit this to the cells in which the spores are formed, being therefore the organs of nutrition; the others white and opaque, terminating externally also, but conveying air to all parts of the body, and bringing the whole into contact with the sporigenous cells.

The spores are developed freely in the vesicular cells destined to produce them. They are limited in number in each vesicle; less than two is never seen in one vesicle; the hexagonal basket-work arrangement of each seed appears to close with a lid, and ten or twelve short spines project out from every point.

Beneath the external dark-coloured reticulated membrane is a second integument, smooth and transparent, easily separated by maceration, although it resists the action of chemical agents, and is not coloured by iodine. The simple cavity of the internal spore is filled with minute granular particles and oleaginous globules, suspended in a fluid probably albuminous, as well as the various chemical salts found by Riègel.

To proceed further with our microscopical investigation of the truffle will give no further insight into its minute structure, but it may be of interest to note a somewhat remarkable appearance during my examinations. Having cut the thinnest possible sections with a cataract-knife, moistened them with a single drop of distilled water, and subjected them to pressure under a Powell's compressorium, I watched with interest a series of currents round the circumference of the sections twofold in direction. I, as usual, attributed these to the capillary action exerted between the plates of glass. Putting them aside for an hour and again examining them, this time using a higher power and eye-piece, I noticed an intense action was still going on all round the edge of the glass cover, exactly resembling the ciliary action round the mantle of the oyster; at certain points losing the character of currents and presenting the appearance of myriads of atoms moving rapidly about, as in the phenomenon of "swarming" amongst the Desmids.

The sections were at the end of another hour removed from the compressorium, and kept moist by adding a drop of dilute

acetic acid; and in a few days they were once more subjected to an examination; when I found the *Anguillulæ aceti*, vinegar eels, developed in large numbers; and all the albuminous portions of the section eaten out or destroyed. It is just possible that the motion observed was produced by the presence of minute ciliated ova of the Anguillulæ;* and their subsequent development may have laid the foundation for the fly-theory formation of truffles.

* This is not very probable, for the author observed the ciliary action before applying the acetic acid. The eels are developed in vinegar *only*, without the addition of any decaying organic substance.—Ed.

DESCRIPTION OF PLATE XXVII.

Fig. 1. A small truffle (natural size) from which a slice has been cut to show its internal structure.

Fig. 2. A horizontal section of a large truffle (natural size).

Fig. 3. External cortical layer magnified 250 times.

Fig. 4. Internal structure. *a*, *a*, Sporangia; *b*, *b*, filamentous mycelium, magnified 250 times.

MISCELLANEA.

CHRONOMETERS AND ELECTRICAL CLOCKS.*

THE reason why the exertions of men of science are not always fully appreciated by the world at large is because the fruits of their labours do not in every case become immediately manifest. It often happens that a whole lifetime is spent in patient toil before the attainment of any considerable results, and even when these are published in the form of some new discovery, or the perfecting of some wonderful invention, the author is too often overlooked by the excitement-seeking crowd.

Thanks, however, to the advancing intelligence of the day, this is not likely to be the case much longer, and even now the worker in science is becoming better understood and appreciated, and is beginning to be highly respected by those who have no pretensions to more than every-day information.

Men are beginning to find that Science really has some direct and immediate connexion with their pockets and with their palates. Here, one misses a bargain because he has allowed the time-ball to drop before he was at his appointed post; there, another loses his train or his packet because he had neglected to set his watch by Greenwich time. And so men are reminded by their very business, and by their domestic habits, that whilst Science is willing to be impressed into their service for gain, she visits with absolute punishment those who neglect her advantages or underrate her importance.

When the trader finds that he has missed his bargain, his train, or his boat in consequence of the precision with which matters are conducted under the régime of Science, he ceases to despise Electricity and Astronomy, and may even go so far as to inquire into their practical application, and to promote it by contributing a mite from his well-filled purse to some useful or fashionable scientific association.

Such inquiries, too, lead him to discover the fact that more important issues are dependent upon the researches of men of science than his little bargains, his pleasures, or his disappointments. He finds that the fate of hundreds of human beings (including, perhaps, that of some dear friend or relative) may be sacrificed at sea in consequence of the want of scientific knowledge on the part of him to whose care their lives are entrusted. He hears that some careless mariner has failed to correct his timepiece, and that a sacrifice of life has been the consequence; but had he taken up the report which now lies before us, he would have known that "an error of two minutes

* Report of the Astronomer to the Marine Committee, Mersey Docks and Harbour Board.

in a ship's chronometer" may cause a wreck with all its disastrous results; loss of life and property at sea, destitution and mournful misery on shore!

Surely, then, the man of science who provides the means of obviating such terrible evils as these is entitled to the gratitude and respect of his fellow men!

But the details of those patient and laborious investigations of which the world at large derives the practical benefit (often without knowing the source from whence it proceeds), are frequently clothed in such technical guise that a record of them would be unintelligible to a vast number of persons whose curiosity and interest would prompt them to seek such information; and this is another reason why the vigils of the worker often remain unknown and unrecorded, except for the benefit of a privileged few; and consequently his trials and difficulties do not meet with that reward which the world would be willing to bestow.

Now, although we do not mean to say that these observations apply in their entirety to the instance before us—for the labours of Mr. Hartnup, the able representative of Astronomical Science in Liverpool, are well understood and appreciated, and their practical results *force* themselves upon the notice of all who take the least interest in the subject—we may still adduce this as an example of what may be done by patient and arduous toil, without being fully recognized by the public at large; for we venture to affirm, that, many as are his friends and supporters who will have carefully perused his interesting pamphlet, they are far outnumbered by those who will have laid it aside without at all inquiring into its importance or the records of progress which it contains.

Possibly they may have been so unfortunate as to open it at pages 10 and 11, and, terrified by the long array of figures, they may have mistaken it for a table of logarithms, or something equally unintelligible to the mind commercial; but had they turned over another page they would have found that to Mr. Hartnup they owe the accuracy of their gold timepieces, and that his labours are intimately associated with all their mercantile concerns.

And now, what does this pamphlet really tell us? As the expositors of Science, standing between the abstruse and popular inquirer, we will endeavour, after our own fashion, to interpret its contents.

The Liverpool observatory is placed under the direction of John Hartnup, Esq., F.R.A.S., a well-known and highly esteemed astronomer and meteorologist, and perhaps his most important duty, one which cannot be too highly estimated, is the correction of ships' chronometers by the means of instruments and appliances placed at his disposal by the Mersey Dock Board. Upon the accuracy of a ship's chronometer may hang the lives of thousands, the issues of peace and war, the fate of individuals and of nations, for it is now employed not only to indicate the hour of the day, but also for a much more important purpose, for "if such clocks or watches could be made to show the correct Greenwich time at sea, then the mariner, on finding his local time by the position of the heavenly bodies, would know his longitude from Greenwich." We must presume that the reader understands the *rationale* of this statement, and he will perceive that an error of a few minutes in the captain's timepiece may take him out of his course, delay the delivery of his despatches, or lead his ship to destruction. For the purpose,

then, of testing the accuracy of such instruments as are confided to his care, under every condition of climate in which they may have to be employed. Mr. Hartnup has an apartment suitably fitted up in his observatory, and ingeniously heated with gas, in such a manner as to secure for him, if requisite, a considerable variation of temperature; and in this room there are ranged, side by side, from 100 to 200 ships' chronometers undergoing the strictest comparative scrutiny.

The formidable list in the report to which reference has already been made, is simply a record of the variation of sixty-two chronometers which were compared and tested during five weeks in April and May, 1861, and also in November and December of the same year; and glancing our eye over the first column, we find that for the week ending November 9th, the mean daily rate of variation in the *least* accurate of these instruments was fifteen seconds, whilst the *most* accurate showed *no variation whatever;* and the average error in the whole sixty-two appears to be about 3½ seconds per day. This speaks well for the makers of these instruments, upon the accuracy of which, as already stated, so many interests are dependent.

The Astronomer of the Mersey Docks and Harbour Board does not, however, limit the employment of his energies to the attainment of precision in the working of marine chronometers for insuring the safety of life and property on the high seas, he also influences the movements of his townsmen through the time-balls and town-clocks which serve as their guide in daily life; and although perhaps not the most important, this will be to our readers the most interesting portion of his labours, and we shall communicate the results obtained by him in the words of his report:—

"All other observations taken with the Transit Instrument have been used for the determination of Greenwich mean time, which has been regularly communicated to the port by means of time-balls and clocks. The large clock in the Victoria Tower has six dials, each of which is eight feet in diameter. This clock has now been successfully controlled from the Observatory for upwards of two years, and the first blow of the hammer at each hour of the day indicates Greenwich mean time. On a calm day the striking of this clock may be heard at the Observatory, and we frequently compare it with the Normal clock. The time which sound takes to pass from the clock to the Observatory is two seconds and six-tenths, and so perfectly does the small clock at the Observatory control the large one at the Tower, that no sensible difference between the calculated and observed time can be detected. The striking is not, however, the most convenient test that we have of the accuracy of its performance. The large clock is made to send a galvanic current once every minute, and by so doing the needle of a delicate galvanometer is deflected at the Observatory, and the deflection of this needle is found to be simultaneous with the beat of the Normal clock. I am not aware that any clock so large as this was ever before made to perform with such marvellous accuracy. The mechanical arrangement for making this clock drop the time-ball has been found to answer well. For communicating Greenwich mean time to ships lying in the river or docks, a time-ball in so conspicuous a place as the top of the Victoria Tower is, I believe, the best means that could be adopted; but, for the convenience of those engaged in the manufacture and regulation of chronometers, and for the public in general, a clock

showing the hours, minutes, and seconds, from which the time may be taken at any instant throughout the day, appears to be the most highly appreciated. As a proof of this, on the 4th of February we caused to be counted the number of persons who appealed to the clock controlled from the Observatory, which is placed in the office window of the Magnetic Telegraph Company, and visible from the Exchange flags, and between the hours of six a.m. and five p.m. eighteen hundred and sixty persons took the time from this clock.

"It is scarcely possible to estimate the value of this extensive dissemination of accurate time, without referring to the various letters and memorials on this subject, addressed to the authorities of Liverpool, during the two or three years preceding the erection of the Observatory. They all dwell very largely on the importance of publishing, officially, accurate time for the benefit of mariners, chronometer-makers, and others; and it is stated in a memorial from the British Association for the Advancement of Science in 1837, that a captain could not at that time obtain the correct error and rate of his chronometer, as celebrated chronometer-makers had been found to differ from each other in the Greenwich mean time to the amount of two minutes. The memorial ends with the remark,—'these two minutes might cause a wreck.'"

By means of his "Rain-gauge," "Barometer," and "Anemometer," the downfall of rain, pressure of the atmosphere, and direction and force of the wind are daily recorded; and Mr. Hartnup is about introducing into the Observatory a new barometer, of which we hope one day to be able to give a description to our readers.

Concerning this instrument he reports as follows at the conclusion of his pamphlet:—

"The new self-registering barometer which is now being constructed, will make our meteorological observations much more complete. Some delay has been caused in the construction of this instrument by our requiring it to be different to those in general use. The record is usually obtained by photography, and as the tracing has to be developed, it is not available for some time after it is taken. For nautical purposes it is necessary that the changes in the pressure of the atmosphere should be seen immediately. We have therefore been obliged to adopt a different plan to that which is generally employed."

How completely interlinked the Arts and Sciences are becoming; and how mutually dependent one upon another, when the record of the state of the atmosphere must be made by photography! How rapid the increase of knowledge, and of man's wants, when even that process is not sufficiently subtle for his purposes!

PROVINCIAL INSTITUTIONS AND SOCIETIES.

The amount of space occupied by our Exhibition notes and deferred articles precludes us from giving to this section of our periodical the attention which it merits, and we shall therefore postpone the consideration of the progress of Field Clubs, Science Schools, and Philosophical Societies until our next issue.

REVIEWS.

The Student's Manual of Geology. By Professor J. B. JUKES, M.A., F.R.S. Black.

WHEN one remembers that in a subject so well understood as arithmetic, it is only within the last few years that a good student's text-book has been written, it is perhaps too much to expect perfection in any manual of geology. Nor is it to be found in this one, which is sometimes dwarfed in plan, and occasionally erroneous in theory and fact. It is, however, by far the best book in our language for the real student: philosophically conceived, it treats in dependent succession, and at length somewhat commensurate with their relative importance, of all the subordinate parts of geology. It has been too much the custom to give in manuals only some of the last results of science in the history of the earth's crust; here, however, the student is introduced to the machinery by which these conclusions are won, and by mastering which he may work out more. The first part, admirably treated, and forming half the book, deals with rocks from a physical point of view; the second part is palæontology and limited to fifty pages; so that the third part, which is the history of stratified rocks, worked out by means of geognosy and palæontology, does not follow naturally. This subject of old life might have been treated typically, without trespassing on Owen's "Palæontology," so as to give the student better help than the chapters on laws of life, which are in many cases only guesses never yet challenged; the third part is excellently illustrated with figures of 320 of the more characteristic fossil species, and numerous sections and diagrams, of which the book contains 125. In this portion the author's careless treatment of the biological part is occasionally evident in the way in which genera still living are marked as extinct. These, however, are slight defects, and of no moment for the student, who will treasure the book, and find himself enticed onwards by the luminous writing.

RECENT WORKS ON ASTRONOMY.

The Orbs of Heaven. New Edition. *Popular Astronomy.* New Edition. By O. M. MITCHELL, LL.D. Routledge.

PERHAPS, as Professor Mitchell is an American, and as his country has of late been associated in our minds chiefly with strife and bloodshed, there may be many amongst our readers who have neither heard of him, nor yet had the privilege of reading his works.

If so, we recommend them to read "The Orbs of Heaven;" and then we think that we may safely leave them the option of perusing his "Popular Astronomy."

"The Orbs of Heaven" left an impression upon our mind somewhat resembling that which we experienced on reading Moore's "Epicurean," so rich is it in imagery and poetry; and, certainly, we have never met with a work so well adapted for encouraging a taste for science. The poetical conceptions of the author, or rather we should say, the poetical embodiment of scientific facts, which come upon the reader by surprise in various parts of the work, cause it to read more like a fairy tale than a record of scientific discoveries; and we never recollect having read anything by which we were so much enchanted as by his description of the lonely astronomer, who, from his "rocky home," witnessed the eclipse which he had predicted; and whose soul was stirred to praise his Creator, the great God whose hand guided the spheres in their path, whilst, in the valley below, stricken millions fell to the ground in despair, or sought by the clangour of brazen trumpets to conciliate their offended deities!

Again, in treating of the stability of our solar system, he shows how certain slow changes are taking place in the orbits of the planets; how these are expanding or contracting, and rocking up and down; that all these changes, however, have their limits; and when, he says, these variations shall, after a series of ages, have attained their maximum, and before a new cycle of movements shall be inaugurated, "*the great Bell of Eternity will then have tolled* ONE."

We recommend every parent who desires to inculcate in the minds of his children a love of science and admiration of the grander aspects of nature to place in their hands this attractive volume; and lest some youth might be tempted from its perusal to take up Professor Mitchell's other work, "Popular Astronomy," and should do that of which few youths are guilty, viz., read its preface, we recommend the publishers to omit this elegant and remarkably grammatical appendage from their next edition. We find it difficult to believe that it has been composed by the author of "The Orbs of Heaven."

As a handbook, "Popular Astronomy" does justice to its title. It is easy enough for young beginners, diversified here and there with sketches of the past history of science, and illustrated with tolerably good woodcuts. Of a totally different character is the little brochure, entitled

The Hand-book of Astronomy. By G. F. CHAMBERS, F.R.A.S. Murray.

IF the reader simply desires amusement, he had better not open the pages of this book. If he wishes to form a fair conception of the appearance of the heavenly bodies through the telescope, then let him glance at the beautiful plates with which it is illustrated; and should he desire to become a student of astronomy, we venture to say that such a cursory glance will tempt him to dive into its contents; but he must be prepared for *work*—for earnest work—such as Mr. Chambers has done in compiling this excellent text-book.

The author has availed himself of every legitimate source of information,* in addition to his own experience, and has spared no pains to bring his treatise up to the latest date.

As our readers will have observed from these few remarks, we do not regard this as a popular work on astronomy in the general acceptation of the term; it is one that is likely to find favour in schools of every description, more especially do we recommend it to teachers in science classes.

The Common Sights of the Heavens, and how to see and know them. By Capt. DRAYSON. Chapman & Hall.

A LITTLE work which professes to give "a simple description of the various sights which can be viewed in the heavens during the day and night." This task is accomplished in a very creditable manner. The writer treats successively of the Sun, the Moon, Venus, Jupiter, Mars, Saturn, the rest of the planets, the fixed stars, comets, and meteors. He describes graphically the appearances presented to the naked eye, and those which are brought within our reach by the telescope. In explaining the changes and motions which distinguish each of the heavenly bodies, he uses language which is singularly clear and simple. He imparts an additional charm to the subject by comparing the probable climatic or other conditions of the various planets, &c., as indicated by the obliquity of their axes, and the period of their rotation with the similar conditions now existing on our own earth. Thus he shows that great extremes of heat and cold obtain successively over the larger portion of the surface of Venus; whilst Jupiter has an exceedingly equable climate. By means of diagrams many important astronomical truths are elucidated. The illustrations consist of carefully-drawn chromo-lithographs; the heavenly bodies being represented on a blue ground, a system which has of late found considerable favour, being employed in both the works already noticed, and very successfully in Keith Johnson's "Atlas of Astronomy."†

With regard to the work under consideration, we may remark further, that it describes easy modes of discovering the position of the chief planets and fixed stars for many years to come. In short, it is a work admirably adapted for exciting the interest of the young in some of the many wonders which are the province of astronomy, and for explaining its chief laws in a lucid and agreeable manner.

It is, however, very much to be regretted that the author has given free license to his speculations. The book abounds in theories with regard to the origin of the worlds and their present condition, very many of which are merely fanciful, whilst not a few are unfortunately at variance with the present state of scientific knowledge. Thus he thinks the sun may

* Amongst other authorities Mr. Chambers draws very judiciously upon Galbraith and Haughton's "Manual of Astronomy," recently published by Messrs. Longman, one of a well-known and serviceable series, edited by the two learned Professors at Dublin University.

† Edited by Hind. Blackwood.

be as cool as the earth, that its particles may be charged with a "subtle force somewhat similar to electricity," which produces heat and light only when entering an atmosphere; and that the rotation of the sun may "in some way" cause the rotation of the various planets; that the volcanic condition of the moon is caused by its long-continued exposure to the sun's heat, a rather extraordinary assumption; that the moon may attract the waters of the ocean or the atmosphere, and, then, by the "subtle chemistry of nature," form one for herself, from the materials thus procured; that a dense atmosphere might cause the smouldering volcanoes of the moon to "burst out into fierce flames;" that comets may be "the agents for gathering up all those gases or used vapours which may be thrown off by the sun and planets," and so on. The writer, again, confounds magnetism and electricity, and thinks the Aurora may be caused by the escape of a superabundance of magnetism in the earth, and by the rapid passage through the atmosphere of the "magnetic element," a state of things not recognized by the science of the present day. It is attempted to be shown that the present condition of some of the planets may be similar to that of the earth in former geological periods. Thus he supposes Venus to be at present passing through a glacial epoch, although on the earth we find glaciers (and, therefore, icebergs) only in connection with perpetual snow—and the conditions in Venus are against the probability of snow being there perpetual. We may remark, in passing, that the mammoth is described, perhaps to give a popular idea of it, as a "gigantic bull;" we think it would have been equally popular, and at the same time more strictly scientific, to call it an elephant.

We might allude to other instances of inaccuracy besides those already quoted, but enough has been said to show how necessary it is for scientific writers to be guarded in speaking of those branches with which they are imperfectly acquainted, and no man can be acquainted with every branch of knowledge. But it is far more difficult to eradicate an error than to inculcate a truth; and it is of special importance in books intended for the young, that nothing should appear in them which is inconsistent with sound science. With these exceptions we can heartily commend Captain Drayson's interesting little volume to our youthful readers.

The last but by no means the least interesting astronomical treatise which we have to bring under the notice of our readers is—

A Survey of the Astronomy of the Ancients. By Sir G. C. Lewis, Bart. Parker, Son, & Co.

THIS book, as its title indicates, is of a totally different character to the preceding ones, dealing only with the ancient theories of the universe; and there is one word broadly stamped upon its pages; namely, "care." No statement is advanced, no theory confirmed or contradicted, before every authority has been carefully considered, and an unprejudiced judgment arrived at; and we have seldom seen a treatise which bears the marks of such patient research as the one before us.

Neither need the author regret the pains which he has taken to prepare the "survey" with the utmost accuracy, for he has rendered it a most valuable work of reference for students, in whose minds it will clear up many doubts.

For example, if a tyro were to take up two of the works already referred to, which do not pretend to treat of ancient astronomy, he would find in both of them that the Pythagorean and Copernican systems of the universe are regarded as identical, or nearly so, each having the sun for its centre. The uninitiated student would be puzzled to find these two systems confounded, for it is generally understood that there was a great difference between the theories of the two astronomers who were 2,000 years removed from each other.

A reference to Sir George Lewis's book will, however, explain the difference between the two theories:—

The Pythagoreans believed that the earth and the heavenly bodies, *including the sun*, revolved around a "central fire," a body of which they had but a vague conception; whilst Copernicus placed the sun in the centre, and thus propounded the true solar theory. Pythagoras and his school may be compared to the man who, after a life-long effort, catches a glimpse of some new theory, or constructs the model of some valuable machine, which is rendered useless by its imperfection; whilst Copernicus resembles some gifted successor, who, having had the benefit of his ancestor's experience, coupled with that of intervening ages, sets his mind to work, and completely solves the problem, propounded and in part unfolded by his predecessor.

Of Sir George Lewis's book we are compelled also to say that it can hardly be termed "popular;" but it will be found interesting to all students of the science, and will be largely employed in educational establishments.

The second portion of the volume is devoted to chronology, and has given rise to a controversy on "Egyptology;" on the construction of the records left by the Egyptians concerning the history of our race. It has nothing to do with the subject of astronomy, however interesting it may be, and ought to have been more clearly separated from the first portion of the work; for as it stands at present the reader is led to expect a return to the original subject, an expectation in which he is doomed to disappointment. We have said enough to show how highly we value this instructive work, and recommend it to the perusal of all who are interested in the history of astronomy in past ages.

SCIENTIFIC SUMMARY.

QUARTERLY RETROSPECT.

ASTRONOMY.

The Missing Nebula.—"The lost Pleiad" has at length reappeared (although with greatly diminished lustre), but it has hitherto been only visible in the gigantic Pulkowa refractor. Having received information of its disappearance in December, 1861, M. Otto Struve lost no time in turning his great telescope to that part of the heavens, and on the first favourable night (December 29, 1861), after the usual few preliminary adjustments of the eye (in adapting it to the detection of faint objects), he had the pleasure of distinctly recognizing "some traces of nebulosity to the south of a star of the eleventh magnitude." M. Winnecke confirmed the observation,—assigning to the nebulosity the same position as M. Struve. Three months of unfavourable weather at St. Petersburg followed this bright night; and it was not until the evening of March 22 that any further opportunity occurred of inspecting the object. On this latter occasion, however, the correctness of the previous observation was fully established. The nebula appeared considerably brighter than in December, so much so as even to allow a slight illumination of the field of view. The sketch given by M. Struve fully agrees with that observed by the writer of this notice in 1855, showing a small elliptical nebula of two minutes in length, much brighter at one extremity than the other. The celebrated observer who detected the reappearance of the nebula, is of opinion that it is variable in lustre,—that its light had considerably increased between December and March, although he thinks that the extraordinary transparency of the atmosphere in the latter month may have added to the contrast. As an example of contradictory evidence, and of the little reliance to be placed on negative evidence, it may be stated that M. Julius Schmidt (of the Athens Observatory) was looking for the nebula on the nights of March 19, 20, 21, 24, and 25, in a perfectly clear sky, but not the least trace could be perceived of it. On March 26 and 27 the same result happened, although the glasses of the refractor were cleaned in the meantime, and precautions were taken to hide the light of some small stars in the field. The sharpness of M. J. Schmidt's vision and his conscientious accuracy are so well known, that this is not of the least detriment to his talents. It is of the statements of those observers who see everything, with the smallest telescopes and under the most adverse circumstances, that we are suspicious. M. Schmidt had a smaller telescope than M. Struve—had he had the assistance of a sixteen-inch object-glass we have no doubt but that he would have succeeded equally well. M. Schmidt adds

something to the history of this object ;—he looked for it in 1860 and 1861, but it was "nowhere."* The last observation of D'Arrest is Jan. 12, 1856, although the writer of this notice is of opinion that it was seen by him in the latter end of that year.

Companion of Sirius.—The existence of a companion of this, the brightest star of the Northern heavens, is now beyond doubt. As previously noticed, it was discovered by Alvan Clark, with his new equatorial of 18½ inches aperture, at the beginning of the year, and his observation was speedily confirmed by Professor Bond, of Cambridge (U.S.), on February 10 ; at Paris on March 20, and, finally, by M. Lassell at Malta, on April 11. But although thus distinctly verified, the micrometrical measurements, as M. Lassell notices, greatly differ. For instance, on February 10, the distance was measured at 10 seconds and 37 hundredths ; on March 20,* at 7 seconds and 4 tenths ; on April 11, at 4 seconds and 92 hundredths. M. Lassell however adds, "I cannot accept the conclusion that there can have been a real motion in the star sufficient to reconcile these measures." The difficulty of micrometrical measurements with a flashing star like Sirius will be readily comprehended by all astronomers. It remains to be seen whether the companion is physically or only optically connected with the large star—in the last case similar in type to Beta Orionis and Antares.

Mountains on the Moon.—Mr. Birt announces the rediscovery of the missing lunar crater *Alhazen*, situated on the western border of that conspicuous object—the *Mare Crisium.* It was first noticed by Schrœter, who employed it for measuring the libration, after which some confusion appears to have arisen, and it was even supposed to have disappeared altogether. The Rev. Mr. Webb has given the full history of its changes as observed by Schrœter, who considered that its appearance was too variable to be accounted for by the varying angle of illumination. At first Schrœter observed it as a dark grey spot ; at other times he perceived it as a very deep crater, with a small shadow. Mr. Birt, upon attentively considering this object, has reason to think "that it consists of two nearly parallel ranges of mountains—the Eastern range forming a part of the actual border." He appears to think that the appearance of a crater is produced by the varying shadows on the surface of the moon by those two mountain-ranges. It is satisfactory to know that the observations of different observers between 1823 and 1829 have been confirmed.

An important work on the topography of the moon has just been announced, which calls into requisition the valuable aid of photography to give a "local habitation and a name" to the various features of the lunar surface. It is entitled "Our Satellite, a Selenography according to the present State of Science, by Dr. A. Le Vengeur D'Orsan." It is inscribed by permission to Lord Brougham, and receives the high commendation of the Astronomer Royal. The first photographers of the day are said to have borne testimony to the value of the illustrations, which include numerous woodcuts

* There appears to be some error here. On referring to M. Chacornac's measures, we find that the distance on March 20 was 10·4″, and on March 25, 10·43″, agreeing very closely with Mr. Bond's measures on February 10. M. Lassell derives his information from *Galignani.*

and lithographs, where accuracy of detail has been principally kept in view. We trust that "Our Satellite" may be liberally patronized and find a place both in the libraries of the learned and the drawing-rooms of the rich, where the beauty of the photographs will no doubt be fully appreciated.* The publisher is A. W. Bennett, 5, Bishopsgate Street Without, and the first number is to appear on July 1.

New Comets and Planets.—We have not to record any discoveries in those objects during the last quarter. It may astonish many, however, to learn that the great comet of July, 1861, is still visible. It was observed, between March 20 and April 16, at St. Petersburg. On July 1 it comes within a degree of the North Pole, at about four hours of right ascension; but, it is needless to add, that it can only be perceived by the help of the most powerful telescopes. M. Struve thinks that the light of the comet is variable, and does not depend on the distance from the sun and earth altogether. On April 16 it showed distinct traces of concentration. The orbit, calculated by M. Seeling, and which gives a period of 419½ years to this comet, appears from those later observations to be the most correct. In regard to planets, it may be stated that between May 29 and June 13 of 1861, an object was observed for Maja, at the Hamilton College Observatory (U.S.), which turns out, however, to be a different object. It has received the name of *Feronia*, and is No. 71 of the group of asteroids. It may be expected to reappear in the month of September, when, no doubt, it will be eagerly sought after. The comet of Encke was observed by Mr. Hartnup at the Liverpool Observatory up to January 25 of the present year. On March 22 the comet of July, 1861, was estimated of the same brightness as the "missing" nebula by M. Struve.

Solar Spots, &c.—A circular spot seen upon the sun's disk, in 1862, March 20, between 8h. 37m. and 8h. 59m. A.M., is worthy of notice from the extraordinary motion which was perceptible. It was observed at Manchester by W. Lummis, Esq., whose observation was confirmed by a friend. During the above interval it appeared to move over about twelve minutes of arc; although, from the diagram communicated, Mr. Hind thinks it could not have been more than six minutes. The spot, according to Mr. Lummis, was quite circular, perfectly defined, and about seven seconds in diameter. The sun was particularly free from spots for several mornings previously.

Planets.—Mars will be a very conspicuous object during the autumn months, arriving at opposition at the beginning of October, when his apparent diameter will amount to 22 seconds. As this planet is above the equator at this epoch, it will be much more favourably seen than during the opposition of 1860, when, although its diameter amounted to 22·6 seconds, it was at the same time 28 degrees of south declination, which, of course, made any delicate observation almost impossible in those latitudes. Many years must elapse before the planet will be seen again to such advantage.

Variable Stars and their Measurement.—The subject of variable stars is one

* We have seen two or three proofs of these photographs, each of which represents different portions of the moon's surface, and consider them very well executed.

of great interest to the amateur astronomer, who, by constant practice, can bring his eye to detect very small fluctuations of brightness. As an example of the exactness with which their periods are determined, we might cite the case of the star S Cancri, the minimum of which was observed by M. Schmidt, at Athens, on April 16, 9h. 27·5m., or within one-third of an hour of the time foretold by Professor Argelander. Mr. Searle, of Cambridge (U.S.), proposes a very simple photometer, consisting of a plate of glass the faces of which are inclined to each other by a few minutes of arc. By covering the object-glass of a telescope with this, the image of a brighter star can be reduced to that of a fainter one seen with the full aperture, and comparing the areas of the covered and uncovered parts of the object-glass, the real light of the two stars may be arrived at, taking into account the absorption and reflection of the plate. It is doubtful, however, whether the older and simpler plan be not more commodious and gives equally good results.

Variable Nebulæ.—M. Schmidt points out that a small nebula, whose place for 1855 is 11h. 16·5m. of R.A. and 90° 22′ of N.P.D. (inserted in the Bonn Star Maps), and which should be visible with a two-foot telescope or comet-seeker, has become so faint that it is seen with the greatest difficulty with the large refractor of the Athens Observatory. There can be no doubt of its former lustre and its present faintness. As this object is now visible in the heavens, perhaps such observers as possess good telescopes may turn their attention to this interesting object. Sir J. Herschel, in a letter to Mr. Hind, furnishes another example of a missing nebula. This one was twice observed by Sir W. Herschel, who, in 1784 and 1787, saw two nebulæ close together, the places of which were respectively 12h. 22m. 14s. and 12h. 22m. 29s., with N.P.D. 75° 33′ and 75° 36′, only one of which is now visible, although they are noted as being of nearly the same brightness. A telescope of four inches aperture should show both objects.

Nebula of Orion.—M. Lassell has discovered a new star in the trapezium of Orion, situated near Theta, which appears to be a full magnitude less than that known as the sixth star. With his giant reflector, and under the transparent sky of Malta, he has obtained some excellent views of this wonderful object, and intimates his intention of making it the subject of a fresh investigation. M. Struve has come to the conclusion, from numerous and careful observations, that the central regions of this nebula are subject to rapid changes of light, and is about to publish an extensive memoir on the subject.

Saturn.—Between May 17 and August 12 the ring of Saturn is invisible. A fine opportunity is thus afforded of observing his satellites. These latter, with their eclipses and occultations, have been seen to great advantage during the present spring. M. Lassell, on one occasion, saw them all in the field at the same time, with the exception of *Japetus.* This distinguished observer is of opinion that if Uranus has more than four satellites, those which are undiscovered are very much fainter than those which are visible in his telescope.

Miscellaneous.—Professor Littrow has discovered in the *Vienna Times* of April 27, 1820, a notice probably bearing on the intra-Mercurial Planet. A round, well-designed circular spot was seen by Mr. Steinheibel on February 12, 1820, at 10.45 a.m., distinguished by its "equally circular atmosphere,

by its orange-red colour, and especially by its unusual motion, completing the diameter of the sun in nearly five hours." Mr. Steinheibel was no novice at solar observations, having pursued those phenomena for many years. The missing nebula above pointed out by Sir John Herschel has been found by M. Chacornac (on April 19). It may, however, have been invisible when looked for by M. D'Arrest. Mr. Dawes has frequently observed the shadow of Titan on Saturn's disc. That satellite will pass over the planet on July 4, 7.30 p.m.; July 20, 6.47 p.m.; and August 5, 6.3 p.m. (these are the approximate times of ingress). He thinks it may be seen by a five-foot telescope of four inches aperture.

BOTANY.

New Upas Tree.—Dr. Berthold Seeman describes a sixth species of Upas, met with in Fiji, which is not, however, absolutely new, though now accurately described for the first time. It appears to have been originally discovered by Dr. George Bennett, of Sydney, after whom it is now named *Antiaris Bennettii.* Though poisonous, its properties are not such as are ascribed to the deadly Upas of Java, and it is remarkable that it always appears in a cultivated state, no truly wild plants having been found either by Bennett or Seeman. It is usually found planted in the neighbourhood of temples, and from the surpassing beauty of its foliage and fruit, it is suggested as a probable future inmate of European conservatories.

New Species of Clerodendron.—The advantages derived from the use of Ward's cases in transmitting plants from tropical countries are well illustrated by the success with which the above plant, Clerodendron Thomsonæ, has been cultivated in the Edinburgh Botanic Garden. It is a verbenaceous, shrubby, twining plant from Old Calabar, whose showy flowers, having a white calyx and crimson corolla, and growing in numerous clusters, render it a desirable addition to conservatories. It is described, with a plate by Professor Balfour, in the *Edinburgh New Philosophical Journal* for April.

Nardoo Plant.—The fate of the Burke and Wills exploring party in Australia, which started at the end of December, 1860, with the intention of crossing to the Gulph of Carpentaria, has caused so much interest and sympathy, that the above plant has excited considerable attention from its association therewith. When nearly exhausted, the party sought the assistance of the native blacks, who gave them some "pounded Nardoo seed." The Nardoo plant was afterwards discovered by them, but the collecting and pounding of the seed was too much for their reduced strength. Although, however, the blacks live so much upon Nardoo seed, it does not appear to have been sufficient sustenance for European constitutions, for notwithstanding a plentiful supply, Wills expired. Some of the seeds found by his side have reached this country, and an attempt to cultivate them will be made at the Edinburgh Botanic Garden. The Nardoo appears to be a species of *Marsilea*, or Pepperwort, probably *Marsilea quadrifolia*, a cryptogamic plant, allied to the Lycopodiaceæ.

Vegetable Types.—The predominance of these types in Eastern America and Eastern Asia, as compared with the few restricted to Europe and Africa,

combined with other circumstances, Professor Oliver thinks, favours the idea that a migration of forms has taken place north of the Pacific, by an overland communication, which may have existed during the tertiary epoch, somewhere about Behring's Straits, or the line with the Aleutian islands; and to this cause is probably due the community of types in the Eastern states of North America and the Miocene of Europe.

Distribution of Fungi.—The eminent mycologist M. Fries remarks that the lowest forms, as Penicillium, may be found alike on the Alps of Lapland and in the Libyan desert; while, for the higher forms, heat and humidity are peculiarly necessary. Hence the Hymenomycetes and Gasteromycetes only appear when the weather is peculiarly favourable, or after abundant rains. Heat, however, is more essential for plants of higher organization than for ungi, inasmuch as many higher species of Agaric flourish at the close of autumn. M. Fries recognizes the existence of two zones peculiar in their fungaceous growth—a temperate and a tropical zone. In the temperate zone, the Fungi are distributed in a very uniform manner; while in the tropical regions there appears to be a more special plan of diffusion in the several countries. The whole of the rather long paper of this illustrious and lamented mycologist is well worthy of perusal, and of the highest interest. It will be found in the "Annals of Natural History" for April, having been translated from the "Annales des Sciences Naturelles." It originally appeared in the "Transactions of the Academy of Upsala."

Potato Disease.—M. Fries observes that this disease is accompanied by the growth of several species of Mucedo; but their presence, nevertheless, is evidently nothing more than the *consequence*, and not the efficient cause of the morbid affection.

New British Mosses.—Mr. W. Wilson, of Warrington, announces *Bartramia cæspitosa* (Schimper), a Swedish species, in a new marshy spot near that place. *Hypnum Eugyrium* (Schimper) has been found by Dr. Wood, of Manchester, near the Rumbling Bridge, Fifeshire. There are only one or two other British stations known. Several other mosses have been recently added.

Vegetation of the Island of St. Paul.—The Austrian exploring expedition in the "Novara" having investigated the botany of this remarkable island, the results may be summed up in 56 species of plants, independent of moss, besides a few introduced, cultivated species. The former consist of 11 aboriginal flowering plants (of which 6 are grasses and 1 a rush), 2 ferns, 1 lycopodium, 3 mosses, 2 liverworts, 4 lichens, and 33 algæ. The only mould on this island is formed by the decay of the plants, chiefly the grasses, yet it is in some places several feet thick.

The Cotton Plant.—The cultivation of cotton in other countries than the Southern states of America is a subject of much interest. On the banks of the river L'Habras, in Algeria, is a vast plain, containing about 650,000 acres, on most of which cotton would grow. Extensive works for irrigating this district are in the course of construction, and several companies (one of them English), as well as private individuals, are already making a start in this promising field. The climate is healthy, excepting that during August and September ague prevails, which may, however, be in in a great measure avoided with due care; and labour is very cheap.

Several distinguished botanists have recently been called from the scene of their labours. Carl Ludwig von Blume, M.D., of Leyden, died at that city in February; and another eminent Dutch botanist, Willem Hendrick de Vriese, expired at the same place on January 23rd. In our own country, we have to lament the death of Mr. Wm. Borrer, F.R.S., a name indissolubly connected with the subject of Lichenology.

CHEMISTRY.

PURE CHEMISTRY.—Our last quarterly retrospect of Pure Chemistry was introduced by a few facts which had been lately discovered respecting the divisibility of matter. More recent researches have shown that even the incredible numbers obtained in the former experiments fall far short of what we now know must be the actual fact,—in the case, at all events, of some volatile liquids. In the course of some experiments on the absorption of heat by gaseous matter, Tyndall has proved that air, which in its pure state is perfectly transparent to radiant heat, becomes absolutely opaque to that force if it contain a minute trace of some compound gases and vapours. A layer of ammonia three feet long is perfectly black to heat emanating from an obscure source. At a tension of one inch of mercury, the absorption of sulphurous acid is 8,000 times that of air; and the perfectly transparent vapour of boracic ether, at a tension of the tenth of an inch of mercury, has an absorbing power upon heat 186,000 times that of air. It is with this latter body that some most astonishing results have been obtained with respect to the divisibility of matter. By admitting a minute trace of boracic-ether vapour into the experimental tube, exhausting it to the tenth of an inch of pressure by means of air-pump, then admitting pure air into the tube and re-exhausting it to the same tension, the absorptive properties of the vapour could be experimentally observed when only the most infinitesimal fractions of an atmosphere were present. By repeated exhaustions and sweeping out of the tube by pure air, the professor found that the action upon radiant heat of an amount of boracic ether vapour, possessing a tension of only the one thousand and twelve million five hundred thousandth (1-1,012,500,000th) of an atmosphere was easily measurable. The actual weight of boracic-ether vapour present in a cubic inch of air at that tension is so infinitely small as utterly to defy the attempts of the human mind to comprehend it.

Cæsium and Rubidium.—M. Grandeau, whose researches on the two new metals discovered by spectrum analysis, Cæsium and Rubidium, were briefly noticed in our last number, has continued his investigations, and now finds that the latter metal is one of the most widely-distributed bodies in nature, being always present in the mineral constituents of beetroot, tobacco, coffee, tea, grapes, and other vegetable substances. These bodies of course derive it from the soil, and M. Grandeau gives data by which it is shown that the amount annually absorbed from an acre of land by a crop of beetroot is somewhat considerable, and by no means to be neglected by agricultural chemists in their experimental inquiries into the inorganic food of plants.

Eli Blake, jun., of New Haven, thus explains the discovery of these

new and rare metals in Triphyline :—"Having obtained a quantity of the residues of the preparation of lithia from triphyline, which gave, when examined in the spectrum apparatus, evidences of the presence of rubidium and cæsium, I have, at the request of Professor Bunsen, made an analysis of it. After the removal of the iron and phosphoric acid, and the conversion of the sulphates of the alkalies into chlorides, it was found to contain :—

Chloride of lithium	... ...	40·98
„ potassium	... ...	9·29
„ sodium	... ...	50·04
„ cæsium	... ...	0·11
„ rubidium	... ...	0·18
		100·60

"The method of estimating the rubidium and cæsium depends upon the insolubility of the platina chlorides as compared to that of the same salt of potassium ; and the difference of solubility is not so great as to give very accurate analytical results. The above approximation, however, serves to show that, like some other minerals containing lithia, triphyline contains small quantities of these new and highly-interesting alkaline bases."

Fizeau has recorded a curious and somewhat paradoxical experiment on the light evolved by burning *Sodium*. Finding the simple light which a soda compound communicates to a flame, not of sufficient intensity for some researches in which an intense but perfectly homogeneous light was requisite, this experimenter tried the plan of burning the metal sodium in air, in the expectation that, as the combustion was accompanied with an extraordinary development of heat and light, a homogeneous light of the desired intensity would in this way be easily obtained. Upon trying the experiment, however, it was found that the light of the burning metal was quite different in its character to that known as the ordinary soda flame. The latter, when examined by spectral analysis, shows a luminous double line D on a dark ground ; but the former was seen to emit a light which in the spectroscope appeared continuous from the red to the violet, with the exception that the line D stood out perfectly black on the luminous ground. This unlooked-for phenomenon, strange as it may appear at first sight, is, however, in strict accordance with theory. The fact that the bright sodium lines can be *reversed* or changed to dark ones by passing through a layer of heated sodium vapour is well known, and forms the fundamental point of Kirchhoff's theory of the constitution of the sun. The simple explanation of the black lines in the above experiment appears therefore to be, that the sodium compounds formed by the very rapid combustion of the metal were carried up into the flame in the solid state, and heated to whiteness, when they emitted light of every degree of refrangibility : a layer of ignited sodium vapour being in front of this continuous spectrum carved out of it the black lines.

Before we leave the subject of *Artificial spectra*, we may refer to a method lately given by Crookes, by which these can be observed in great perfection with very simple apparatus. The beauty and perfection of a metallic spectrum depends in general upon the heat of the flame. In order to bring

out some of the finer and characteristic lines, complicated electrical apparatus has hitherto been employed. Crookes, however, has shown, that by employing the metallic compounds in the form of chlorates, many, if not all, of these brilliant appearances can be produced with the ordinary gas flame. He describes the greatly-improved appearance which is thus obtained when baryta, strontia, lime, potash, soda, and lithia are examined in this way, the brilliant blue line of the latter metal being distinctly visible. The spectra of many of the heavy metals, which cannot usually be seen except with the electric light, can also be submitted to examination.

Professor Zantedeschi, of Padua, is of opinion that the lines in Fraunhofer's spectrum are not all fixed ones, but that some of them are variable. And the general tendency of recent examinations of solar and other spectra is to show that prismatic analysis is not of that absolute and unchangeable character as was at first supposed, but that it is subject, to a small extent, to conditions of temperature, &c.

M. J. M. Leguin has examined the spectra of phosphorus and sulphur by volatilizing those substances in a current of hydrogen. The vapour of phosphorus in hydrogen gives a red ray; an orange ray almost as visible as the red; two less distinct green rays at the more refrangible end of the visible part of the green; and, at a comparatively dark interval, a bluish-green ray; then some feeble blue or violet rays. Of these, the red and bluish-green rays probably belong to the hydrogen. In the sulphur spectrum there is a red ray, and three distinct and nearly equidistant green rays. The three green rays are the most prominent part of the spectrum of sulphur; they were seen with unmistakable precision in sulphuretted hydrogen and sulphurous acid.

The same investigator, in a note to the French Academy of Sciences, "On the Spectrum of the Electric Spark in Compound Gases," states that the spectrum of fluoride of silicium exhibits a large vivid blue ray, very far from the green; and the spectrum of fluoride of boron gives similar results; and he therefore attributes this blue ray to fluorine. He states that, whilst chemical decomposition is being produced in compound gases by the electric spark, the bands in their spectra are not distinct, and the spark is enveloped by a halo; but when the compound gas is nearly all decomposed, the spark becomes slender, and the bands in the spectrum much more distinct.*

The line of demarcation between organic and inorganic chemistry, sharp and well-defined up to a recent period, is now gradually disappearing. Organic chemistry was originally held to include all chemical compounds which required *vital force* for their production, whilst inorganic chemistry treated of all bodies which were capable of being built up from their elements by artificial means. Of late years the progress of science has placed us in possession of means of forming synthetically a vast number of purely organic compounds; and the International Exhibition contains, amongst the chemicals in the French department, some of the most remarkable products which have ever been formed in this way. M. Berthelot exhibits here, for the first time, alcohol, stearin, and other natural

* See also "Physics."

organic products, "per syntheticam artem generatum." As a starting-point, he takes a lump of charcoal and hydrogen gas, and actually forces these two bodies to unite and form the gaseous hydro-carbon, acetylene. This being obtained, he introduces the other elements by appropriate methods of treatment, until he arrives at substances of very complicated formulæ. These researches into the synthetical formation of organic bodies may, to the superficial observer, seem devoid of value; but it must be remembered, that by these researches, which M. Berthelot has for many years been carrying on, chemists are unfolding the laws by which Nature works in her vast laboratories of the animal and vegetable world; and when we remember the vast importance which would attach to the artificial production of such bodies as quinine and morphia, the most utilitarian will scarcely ask what is the use of these fascinating researches.

II. APPLIED CHEMISTRY.

Schroeder has examined the effect of *filtering air through cotton-wool* in its relation to fermentation and putrefaction. The conclusion at which he has arrived is, that air in its ordinary condition contains germs which are removed by passing it through cotton-wool. Organic substances capable of putrefaction or fermentation likewise contain similar germs, which are, however, entirely destroyed by a more or less prolonged ebullition. If, after these have been thus killed, only filtered air is allowed to have access, no decomposition will take place, however long it be kept; but if some of these putrefaction-inducing germs are allowed to have access to the body, either by the ebullition not being sufficiently prolonged, or the air not being effectually filtered, decomposition will be sure to take place. The frequent failures in several domestic and culinary operations are thus easily explained. In making preserves or bottling fruit, for instance, the object is to destroy all the seeds of decomposition present in the fruit, and then to cover the jars tightly over with bladder or paper, so that none but filtered air can have access to it. The object of the preliminary boiling is, therefore, not so much to strengthen the preserve as to kill these germs; and the object of the covering with paper or bladder is not to keep the air from it, but to prevent the atmospheric seeds of decomposition from gaining access.

The process of *galvanizing iron pipes and surfaces*—that is, giving the metal a coating of zinc—is so commonly used under the impression that the zinc, by its polarizing action from contact, will preserve the iron from corrosion; and, as the oxide of zinc formed under such circumstances adheres to the metal and incrusts it with a body not soluble in water, it has been assumed that water passing through such pipes would not become contaminated by either iron or zinc. Dr. Hayes has recently found that this idea is incorrect. Water containing some very common organic impurities has been proved to have a decided solvent action upon both the iron and zinc; galvanized iron pipes exposed to this water not only dissolving in it, but the usually observed protecting power of the zinc was lost—the quantity of salts of both metals in solution being frequently so large as to render the water unfit for domestic use. It is a generally-received opinion that zinc compounds, when taken into the system, are not actively poisonous, if even

harmful. Dr. Hayes, however, has detected several cases of anomalous disease which could be traced to the habitual domestic employment of water so contaminated; and it is, therefore, strongly advised that, before galvanized iron vessels are used for the water-supply of a house, it should be ascertained whether there is any chance of the metal being corroded and dissolved.

It has long been a doubtful point whether *carbonic oxide* was really such a poisonous gas as some writers imagine. Although it is an almost invariable accompaniment of carbonic acid when produced by ordinary combustion, few persons have thought of ascribing to it a share in the calamitous results which have so frequently been caused by the inhalation of the vapours of burning charcoal. The lamentable accident at the Hartley Colliery first directed the attention of several physiologists to the subject, and the result has been that this gas must be now looked upon as a most violent and deadly poison; common air, containing as small a proportion as one per cent., proving rapidly fatal to rabbits and other small animals, and a half per cent. killing small birds in a few minutes. The action of this gas on human beings has frequently been demonstrated. Sir Humphrey Davy, after three inspirations of the diluted gas, fell down senseless, and upon recovering from this, it was succeeded by giddiness, sickness, acute pains, and extreme debility, which lasted for some days. Since then, Mr. Wilter as nearly as possible killed himself by an inhalation of the pure gas. He fell upon the floor in a state of perfect insensibility resembling apoplexy, and with a pulse nearly extinct; his life was only saved by his having pure oxygen gas forced into his lungs. On the Continent the employment of water-gas (a mixture of hydrogen with about thirty-four per cent. of carbonic oxide), as a means of illumination, has been forbidden by law, owing to the numerous fatal accidents which its escape into houses occasioned. These and several other instances, which have been collected together and examined by Dr. Letheby, prove without a doubt that the deadly properties of this gas have not been overrated; and as it has been also proved that this oxide is produced in the combustion of carbon whenever the supply of air is limited,—for instance, in brick-kilns, iron furnaces (about thirty persons having been poisoned at Clayton Moor from this cause), slow-combustion stoves, &c.,—it is important that the public should be well acquainted with the very dangerous properties of a gas to which they are liable by many accidents to be exposed.

An improvement in the *oxy-hydrogen light* has been effected by Mr. Fryer. The earth lime is generally employed as the incandescent body in this means of illumination; but there are several objections to its use which render the discovery of a more efficient substitute advisable. Magnesia has been found to give the best results, as far as light is concerned; but there was a difficulty in rendering it sufficiently coherent to resist the impact of the gases. After numerous experiments it was found that the best results were obtained by mixing together one part of sulphate of lime and two parts of calcined magnesia with water, moulding them into a cake and drying. The illuminating power, pressure and volume of gas being equal, is said to be exactly double that of lime.

Chloride of lime is daily used as a disinfecting and deodorizing agent; but its value as an insecticide is not so generally known: by scattering some of it on a plank in a stable, all manner of flies—even the biting flies—are quickly got rid of. Sprinkling beds of vegetables with even a weak solution of this salt effectually preserves them from the attacks of caterpillars, butterflies, mordella, slugs, &c.; and it has the same effect when sprinkled on the foliage of fruit-trees. A paste made of two parts of powdered chloride of lime and one part of some fatty matter, placed in a narrow band round the trunk of a tree, prevents insects from creeping up it. It has even been noticed that rats and mice quit places in which chloride of lime is occasionally spread. This salt, finely powdered, can no doubt be employed for the same purposes as flour of sulphur, and be spread by the same means.

A very ready *means of purifying chloroform* has been suggested by some experiments recently published by Hardy. Perfectly pure chloroform is not attacked by metallic sodium; but alcohol, wood spirit, hydrochloric acid, and other substances either intentionally added to, or spontaneously generated in chloroform by keeping, are at once acted upon by the alkaline metal with evolution of hydrogen, marsh gas, and oxide of carbon. This reaction takes place in the cold, and is almost instantaneous. After all disengagement of gas has ceased, the chloride of sodium and excess of metal remain at the bottom, and the chloroform, thus freed from foreign matters, is pure.

One of the most novel and important improvements which has been effected for several years in the *manufacture of lucifer matches* has lately been patented by Messrs. Bryant and May. The protection afforded by the use of this match is based upon the circumstance that it will only ignite upon the prepared surface of the box, no ordinary kind of friction being capable of inflaming the combustible materials with which the wooden splints are tipped. The match does not itself contain any phosphorus, but is coated merely with oxidizing substances, such as chlorate of potash in conjunction with binoxide of lead or manganese, and the ingredients are in this manner so divided that it is necessary to employ the special friction surface prepared with amorphous phosphorus in order to secure the inflammation of the match. The security against accidental conflagration is thereby reduced to a minimum; the splints have, indeed, so little of the dangerous character of the ordinary match that this manufacture enjoys the exclusive privilege of being sanctioned and admitted within the building of the International Exhibition. The matches are not coated with sulphur in the usual way, some kind of wax or fatty matter being employed for impregnating the wood. No phosphorus being employed in the match composition, they are, of course, quite free from the unpleasant odour and poisonous character of this substance. The dangerous practice of carrying loose matches in the pockets and about the house, and the common habit among servants of striking them upon the wall to the disfigurement of the paper-hangings, will be altogether avoided by the introduction of this match.

Mr. C. O'Neill has published some valuable experiments undertaken with a view to determine the origin of *paraffin-oil explosions*. The way in

which he tests the oil is to place about a quarter of an ounce into a six-ounce stoppered bottle, and, after inserting the stopper, shake the bottle well for three or four minutes; upon then removing the stopper, a lighted match is held to the mouth of the bottle; if there was a rush of pale blue flame through the bottle, the oil was said to give off an explosive vapour, and according to the temperature at which this test was performed the oil was said to be dangerous or ordinarily safe. Out of thirty-two samples two were found to explode at the temperature of 60° Fah., and were consequently highly dangerous. This temperature can, however, be only considered as the lowest limit of possible danger; the actual limit being a temperature as high as 85° or 90°, which may be calculated upon as often existing in the cistern of a lamp; this high temperature being produced by long-continued burning in a warm room and on a table near the fire. The experiment was, therefore, repeated at this temperature with the remaining samples of oil, when three more were found to be explosive; the other oils were then tested at temperatures of 100°, 120°, and 150°; four of them were dangerous at the first, three others at the second, and the remaining twenty at the highest temperature.

This is, however, beyond the limits of actual danger, and these twenty may therefore be looked upon as very safe oils. The classification of these oils presents several points of interest. They consisted of Young's Paraffin and American oils; the whole of the former were found to be safe, whilst only two American oils were safe, all the others exploding at or below 120°. It must, however, be remembered, that whenever the oils are scattered upon linen or woollen rags, at even the ordinary temperature of the air, they burst into violent flame upon a momentary contact with a lighted match or candle. This is the most dangerous property of mineral oil, and in it there is no considerable difference between Young's best samples of paraffin oil and the worst American oils. Before a fresh sample of paraffin oil is purchased for domestic illumination, it should be tested in this way. The proper temperature can be readily communicated to the bottle and oil, by immersing it in water at 120°, and no oil which gives off an explosive vapour at that temperature should be allowed to enter a dwelling-house. The real danger to society consists in the practice of selling one species of oil for another; *genuine paraffin oil is perfectly safe in a proper lamp; but the majority of the American substitutions are scarcely safe under any circumstances.*

GEOLOGY AND PALÆONTOLOGY.

ONE of the most noteworthy of modern geological discoveries is a strange animal, half reptile, half bird, from the Lithographic slate of Germany. Covering a slab of about one foot and a quarter square, the remains indicate a creature abundantly feathered. A single feather like those of the common partridge, showing the quill and all the fibres of the vane beautifully preserved, had been previously described from the same deposit by Von Meyer; but this fossil, unlike any bird, has the feathers, which likewise show stem and vane, at the extremity of the arm (the hand not being preserved)

radiating like a fan; and those attached to a long tail of twenty vertebræ, radiating laterally so as to form a leaf-like shape broadest at the terminal end. The head and neck are unknown. The feet, like those of birds, consist of a strong tarsus of one bone, trifid at its lower end for the attachment of three toes, which terminate in strongly hooked claws. But, unlike a bird, the joints of the lower part of the back, instead of being united into a large bone called the sacrum, all remain separate; and the pelvic bones, into sockets in which the thigh-bones work, instead of being large and extending along the sacrum, as in birds, are small, and like those of the Pterodactyle. A further peculiarity is the length of the tail, which contains twice as many vertebræ as that of a bird, and, what is more important, gradually tapers to the end instead of terminating in a bone larger than the others. Until more is known of it, and its structure has been carefully compared with that of other animals, nothing but a guess can be given as to whether it is bird or reptile; Von Meyer seemingly inclines to the former view, and names the genus Archæopteryx; Dr. Wagner, however, thinking it a reptile, gave it the name of Griphosaurus. Should the latter supposition prove correct, it will furnish one more illustration of the fallacy of Cuvier's doctrine that an unknown creature can be restored from a single bone; for, had the tarsus only been found, it would as surely have been referred to a bird, as the similar bones from the upper greensand of England.

At a late meeting of the Geological Society, Sir W. Logan exhibited a plaster cast of some remarkable impressions found at the base of the Cambro-Silurian rocks, in the Potsdam Sandstone of Canada. These markings, certainly the trails of some animal, are about six inches wide, with the sides parallel and elevated like a tramway, and extend uniformly over the slab for several yards, sometimes straight and sometimes curved; only a central ridge appears wherever there is a bend. But what is most singular is, that at distances of about two inches there are transverse ridges, the spaces between which are inclined planes deepest in the direction from which the creature was going; so that the trails resemble more than anything a narrow Venetian blind when shut. Nothing whatever is known of the animal except the story told by its tracks. The cross-bar ridges show that it did not move smoothly and uninterruptedly like the hedgesnail and most other molluscs, but with a uniform jerking motion, which suggests the probability of its being a crustacean. The tramway-like ridges which are due to the weight of the body drawn over the sand indicate an animal without hind limbs to support the tail. The inclined depressions behind the cross ridges will suggest that motion was made chiefly by a pair of limbs about the head which were used together, so that by elevating the front part of the rather rigid body the tail was pressed into the sand, when the creature would draw itself along rapidly till its whole length rested on the sand again, just as would a child, trying to move similarly; hence the tail would be drawn out of the depression it first made, then impressed again, and so on. Judging from the short distance between the cross-bars, the legs must have been short. To have made the median ridge visible in the bends, the tail would have been provided with a pair of side-flaps like those in a lobster, which would readily straddle apart as the animal turned round, allowing the sand between to rise in a ridge. All these characters render it likely that the

genus was nearly related to the group Eurypterida which occurs in newer Palæozoic rocks.

Professor Owen has described five new small reptiles from the coal of Nova Scotia, which, from their size and teeth, are supposed to have been insectivorous, so that, could it have been preserved, one might expect to find an abundant insect fauna in these old rocks.

Professor Heer, after a careful study of the plant remains from the uppermost Eocene of the Isle of Wight, has decided that, like the Bovey-Tracey coal of Devon, the beds should be classed as Lower Miocene. It is important, however, as suggested by Professor Ramsey, to remember how slight our knowledge of fossil plants yet is, when it is brought forward to override evidence of the immeasurably better known group of fossil shells. The molluscan remains had scarcely suggested a doubt as to the Eocene age of the deposits; hence it is far from unlikely that the final result of these conclusions by Professor Heer will be to remove into the older formation many beds now believed to be Miocene.

In a new species of Eurypterus from the coal-measures, Mr. Salter finds the sides of the back ornamented with ramifying spines looking like miniature trees, a character which, besides being very beautiful, is interesting as the only case of its kind known in the animal kingdom.

Among the reptilian fossils brought by Prince Alfred from South Africa, is the pelvis of a large Dicynodon, in which the three bones on each side are, as in mammals and some lizards, anchylosed, or united into one bone, forming a strong support for the hind legs; but the anchylosis has gone further than in any mammal, for the two *Ossa innominata*, as these bones are called, are united into one strong hoop. From the strength of this remarkable pelvis on to which the ribs abut, Professor Owen anticipates that, when found, the hind limbs will be large,—keeping the body well off the ground. It may be remarked that this genus has another mammalian resemblance in its two walrus-like teeth.

In the Ránigánj coal-field in India, which is by far the most important, there are 49 collieries, many with several workings, about one half of which are ordinary quarries and the others pits. The thickness of the seam varies from 5 to 35 feet, and except in the thickest deposits the whole depth is worked. This coal is considered by Dr. Oldham (Superintendent of the Survey) as Triassic, on the grounds that it contains a single minute crustacean (Estheria minuta), common in the Trias of Europe; that among the genera of plants, which for the most part range through the Secondary and Carboniferous rocks, there is one hitherto only found in the Trias, and also that Dicynodont and Labyrinthodont reptiles have been found, such as occur in strata in Africa, supposed to be Triassic. It is possibly of this age, as it might be of any other. But the biologist remembering that distribution in space is the index of correspondingly long duration in time, will not regard the age as so well determined that it can be used as a datum for interpreting the much-disputed age of the Australian coal-measures which have some fossils in common.

Captain Playfair, of Aden, reports a volcanic eruption near the Straits of Bab-el-mandeb in May last, accompanied with earthquakes, in which the sky became pitch dark, and the volcano ejected first fine white dust, and after-

wards a red dust which fell knee-deep. The dust continued to fall for several days, and some distance out at sea. At night the mountain Jabel Dubbeh, a day's journey inland, was seen giving out smoke and fire.

In the succeeding August a steamer crossing the Caspian found in its middle a newly-elevated island some 200 feet long and six feet high. The ground, which smelt strongly of petroleum, was still quite soft and difficult to walk on, from the feet sinking in.

In the December following came the eruption of Vesuvius, pouring out one more of the many lava coats which have made up its mass. Preceded by more than twenty distinct earthquake shocks, at mid-day on the 8th, the sky became completely dark over the Torre del Greco, and clouds of ashes were projected out from several jets on the sides of Vesuvius; in the night ashes were succeeded by lava, which in the next morning had so hardened as to bear walking on, though the interior was so hot that a stick put into the cracks took fire. On M. P. de Tchihatcheff approaching the smoking hills, he saw the glowing scoriæ, black ashes, and white steam, thrown out with intermittent shocks resembling the puffs of a steam-engine. The explosions of the new craters, as well as the flow of lava, almost ceased about the third day; but in the mean time the central cone of Vesuvius, previously tranquil, began ejecting ashes and steam in dense clouds, which on the 23rd fell abundantly in the streets of Naples,—an event which has not occurred since 1822. There were in all about twelve new craters formed.

At the same time the shore beneath Torre del Greco was permanently elevated about four feet,—a long line of shells and zoophytes being now raised that height above the sea-level.

MECHANICAL SCIENCE.

EFFORTS have been made at various times since the introduction of railways to reduce the friction of the wheels of the carriages, and so to diminish the tractive resistance which the engine has to overcome. The failure of tyres, leading to frequent and fatal accidents, has of late drawn increasing attention to the subject, and various attempts have been made to remedy the defects of our present system of construction. Friction-wheels for bearings have been tried on the Eastern Counties Railway. Steel wheels and wheels with steel tyres have been adopted to some extent, and Mr. Bridges Adams has invented an elastic wheel, having a spring between the run and tyre, which exhibits great durability. Meanwhile M. Gerard proposes to abandon wheels altogether, and his plans have been experimented upon at the expense of the French emperor. He places the carriages upon sledges, which are hollow, to receive water forced in under pressure: this water passes in a minute film between the sledge and rail, so that the carriage rather *floats* than *slides*, and the tractive resistance is said to be very small. Further experiments under the direction of a commission are contemplated.

Machinery worked by compressed air, like that on one side of the Mont Cenis tunnel, alluded to in our last number, has been employed in hewing coal in a pit near Ardsley, under a patent of Messrs. Donisthorpe, Firth, and Rothery. The air is compressed by a powerful steam-engine at the pit's mouth to 50 lb. per square inch, and thus conducted in bitumenized pipes a

distance of nearly a mile to the cutting machinery. Having worked the pick or cutter, which is under the direction of a single man, the air escapes at every stroke and materially improves the ventilation of the mine. No more legitimate or beneficial application of machinery could well be conceived, nor one more likely to meet with ultimate success than this, which promises to reduce the hardships of a laborious and dangerous employment, and one (in spite of remarkable exceptions) not very favourable to the mental or moral development of the workers.

This year seems likely to be marked by the general adoption of the steam-plough. Machinery has already been applied to all the indoor operations of the farm, but in the field its progress has been slower. Nevertheless, reaping and mowing machinery is in great request, and the steam-plough is at last receiving the attention it deserves.*

MICROSCOPICAL.

Microscopic Life in the Island of St. Paul.—The veteran Ehrenberg has published a paper on this subject, the result of investigations made by the *Novara* expedition at the suggestion of Von Humboldt. The island, situated far out in the Southern Ocean, between the Cape and Australia, is two miles by three in size, and its remarkable position and isolation, and purely volcanic origin, render it highly interesting.

The samples examined by Ehrenberg were specimens of stones from a hot spring, cinders from the coast, coarse black sand, probably magnetic, moss-turf, and earth beneath the turf. In some sand from the hot place close to the shore of the crater basin, he found two Polygastria and three Phytolitharia in an isolated condition. One hundred and fifty-four forms of organisms were met with, of which one hundred and nine were silicious, sixteen calcareous, and twenty-nine soft forms. Nearly half of the whole were independent organisms, and the remainder characteristic parts only, as of grasses and sponges, and twenty-nine were new to the Professor. He believes that in this island an abundant, earth-forming, invisibly powerful organic life is going on.

Revivification of Tardigrada and Rotatoria.—A remark by Professor Ehrenberg is worthy of notice. Among the microscopic forms from St. Paul were some of the above organisms. He says, "I immediately tried with great care whether they would give signs of life in water, or whether they could be brought into full vital activity, which has usually been erroneously described as a resuscitation from death. The dry materials which were collected in December, 1857, and reached me in 1861, and were consequently more than three years old, exhibited no signs of vitality in any of the forms in which these were expected, although in previous experiments with materials from other localities, I had been able to observe life still retained even for four years. We can revive no dead organisms, even the smallest!"

* See Reed's article on the "Agricultural Department of the Great Exhibition," p. 407, in the present number.

Antiquity of Desmideæ and Diatomaceæ.—An examination of the hornstone nodules of the Devonian and Silurian rocks of New York has resulted in the discovery of abundant organisms referable to the Desmideæ, such as numerous forms of Xanthideæ, supposed to be the sporangia (1) of Desmids, and an occasional duplicated (2) Desmid; and lines of cells, some of which appear to be sparingly branched. Besides these were found a few Diatomaceæ. It is observed for the use of those who undertake the investigation of siliceous concretions, that the use of turpentine renders the chips of chert (3) almost as transparent as glass.

Entry of Minute Organisms through the Pores of the Body.—Mr. Carter of Bombay thinks there is reason to believe that the Guinea-worm is a monstrous development of some minute species of free Filaridæ (4), and that these little creatures having a calibre much smaller than the ducts of the sudorific gland, probably pass through those apertures into the human body. He has found them entering thus through the even minuter apertures of a species of Sphæria (5). So also the black Fungus disease of India, as he thinks highly probable, may arise from the entry in the form of a Zoospore, of a species of Mucor (6), through the sudorific ducts.

Foot of the Fly.—Mr. Tuffen West, in an elaborate article in the Linnæan Transactions, has most carefully examined and described this remarkable and complicated organ. With regard to the vexed question of the insect's mode of walking back downward on smooth surfaces, he says, "When a fly is not making use of its pulvilli, as on a surface sufficiently rough to afford it foothold with its *claws* alone, they only are made use of. On a smooth surface, however, perpendicular or horizontal, the pulvilli are brought down, and certain *tenent hairs* (so called because they are the immediate agents in holding, and which project from the inferior surface of the flaps at the base of the claws), are applied to such surface. A slight push forwards of these, succeeded by a gentle draw backwards at each application, removes the air between their soft elastic expansions and their plane of motion, and thus a firm hold is gained. Access of air is prevented by the minute quantity of air which exudes from the expanded tips of the tenent appendages; and thus a vacuum is formed, on the same principle as in the "Atmospheric Hat-peg," or "artificial gums" of the dentist. When the fly wishes to remove a leg from its place of attachment, the claws are brought down and pressed against the surface; from their position they raise the hinder part of the pulvillus, where the tenent hairs are least developed, first, and so on forward. A fly, when once stuck fast, if it had no claws, might remain so. The pressure of the atmosphere is thus the main agent which enables the fly to adhere to perfectly smooth surfaces. The atmospheric pressure on the area of the flaps alone is calculated at just one-half the weight of the fly, that on the tenent hairs at one-fourth more. Mr. West accounts for the remaining fourth by the slight viscidity of the fluid (*sudor*), by grasping, and other delicate and subtle agencies.

Mounting Polyzoa, &c.—The difficulty of showing Polyzoa and Hydrozoa with outstretched tentacles, under the microscope, has been overcome by Mr. J. W. Morris, of Bath, by adding spirits of wine, drop by drop, to water in the cell containing the living animals, which causes them to unfold their arms, and in that condition die. Thwaits' fluid is also recommended.

Structure and Growth of the Tissues.—Dr. Beale in his recently concluded Lectures before the College of Physicians, maintains that every living structure, and every elementary part that is living, is composed of matter which is *forming* and matter which is formed—germinal matter and formed material. He remarks that the *nucleus* of the frog's blood-corpuscle is *germinal* matter, the external red portion (cell-wall, and coloured contents) *formed material.* That the white blood corpuscle, the lymph and chyle corpuscle, and the pus and mucus corpuscle are composed entirely of germinal matter, with a very thin layer of formed material; the viscid matter or mucus between the mucus corpuscles is formed material. The nucleus of an epithelial cell is germinal matter—and in a fully-formed cell, the outer part, cell-wall, or cell-contents, consist of formed material; and so on.

Museum Microscope.—Messrs. Smith & Beck, who are constantly exerting their ingenuity in some new application of the microscope, have exhibited to the Microscopical Society a microscope, under this name, adapted for use in public places, where it may be handled by persons unaccustomed to its use, without fear of destruction or damage. It consists of a microscope-body fixed upon a cylinder of brass which rests upon a cast-iron frame. The brass cylinder has a large series of slides arranged upon smaller cylinders, which by turning a milled head are brought successively before the eye. Moreover, this microscope by a simple adjustment is readily adapted to either of three different powers with which it is supplied.

NOTES.

1 & 2. The Desmideæ are microscopic green Algæ, the germs or capsules of which are termed "sporangia." The cells are formed of two symmetrical valves, the junction being marked by a division of the green tissue. Hence they are termed *duplicated.*

3. Chert, a granular variety of quartz.

4. Filaridæ, microscopic parasitic worms found in the fluids of the body, as in the blood, chyle, and humours of the eye.

5. Sphæria, a very large genus of fungi, of which several hundred species are described.

6. Mucor, a sort of mouldiness, consisting of vegetable cells of a parasitic nature.

7. Pulvillus, a soft, membranous, cleft cushion, situated on the under surface of the fifth tarsal (or ankle) joint of the fly.

MINERALOGY AND METALLURGY.

A PAPER was read a short time since at the Chemical Society of London, by Mr. Frederick Field, upon the "Universal Distribution of Bismuth in the Minerals of Copper containing Sulphur." From an extensive investigation upon the composition of commercial coppers from all parts of the world, conducted by Messrs. Abel and Field, in the majority of which bismuth was detected in very sensible quantities, Mr. Field determined to submit a vast number of copper ores to minute analysis, in order to arrive at a satisfactory conclusion from whence bismuth was derived. Specimens were obtained from various localities in England, Scotland, Ireland,

Wales, France, Spain, Turkey, Russia, Africa, Australia, Chili, Bolivia, Peru, Mexico, and the Northern and Southern States of America. In all the sulphides of copper from these countries, bismuth was detected; but in the malachites and oxides from Australia it was absent.

The increased working of the *mines in Chanaral, Northern Chili*, has developed enormous quantities of the oxy-chloride of copper, a mineral looked upon hitherto as somewhat rare. One of the mines in that neighbourhood has also been very productive of the black oxide, found heretofore in comparatively small masses.

The smelting operations in Chili have been extraordinarily increased during the past year, and the shipments of copper ores have been very large. More than 30,000 tons of copper, in bar, regulus, and mineral, were exported from that country in the year 1861.

Dr. Percy's second volume is expected to appear about December. The author is engaged in many important experiments on the metallurgy of iron, which are looked forward to with much interest.

The Composition of Furnace Regulus.—Mr. Field has written a paper upon "The Composition of Copper Regulus." He had entertained the idea for some years that the first products of the copper furnace had a definite chemical constitution, although they were supposed by the majority of chemists to be simple admixtures of copper, sulphur, and iron, in variable proportions. Mr. Field asserts that one or more equivalents of disulphide of copper ($Cu_2 S$) are associated with one of the sesquisulphide of iron ($Fe_2 S_3$), one of the protosulphide ($Fe S$), and two of the disulphide ($Fe_2 S_3$), in confirmation of which idea he publishes many analyses, among which one or two may be cited.

A well-roasted sample of regulus gave—

Copper	61·34
Iron	15·61
Sulphur	22·90
	99·85

A very fine specimen of copper pyrites gave—

Copper	54·21
Iron	21·43
Sulphur	24·12
	99·76

Experiments on Amalgams.—At a recent meeting of the Literary and Philosophical Society of Manchester, Dr. Joule communicated some very interesting facts on the combinations between mercury and other bodies.

The weakness of the affinity which holds the constituents of amalgams in combination seemed to the author to offer the means of studying the relationship between chemical and mechanical force. His inquiries were extended to several amalgams, and gave results of which the following is a summary:—

Amalgam of iron was formed by precipitating iron on mercury electrolytically. The solid amalgam containing the largest quantity of

mercury appeared to be a binary compound. Iron does not appear to lose any of its magnetic virtue in consequence of its combination with mercury. Its amalgamation has the effect of making it negative with respect to iron in the electro-chemical series. The affinity between mercury and iron is so feeble that the amalgam is speedily decomposed when left undisturbed, and almost immediately when agitated. The application of a pressure of fifty tons to the square inch drives out so much mercury as to leave only 30 per cent. of it in the resulting button.

Amalgam of Copper. By precipitating copper on mercury electrolytically, a mass of crystals is gradually formed. After a certain time the crystals begin to get fringed with pink, indicating uncombined copper. In this state the amalgam is found to be nearly a binary compound. On applying strong pressure to an amalgam containing excess of mercury, the latter is driven off, leaving a hard mass composed of equivalents of the metals; if, however, the pressure be continued for a long time, the resulting amalgam contains more than one equivalent of copper, indicating a partial decomposition.

The author gave an account of his experiments with amalgams of silver, platinum, lead, zinc, and tin. In the case of the latter amalgam, long-continued pressure drives off nearly the whole of the mercury, indicating in a striking manner the efficacy of mechanical means to overcome feeble chemical affinities.

A new Fusible Alloy.—Dr. Wood, who has investigated many of the alloys, has just published a description of a new and interesting fusible alloy. "In the *American Journal of Science and Art* for September, 1860," Dr. Wood says, "will be found a notice of the cadmium alloy, discovered by me, consisting of from one to two parts of cadmium, two parts of tin, four parts of lead, and from seven to eight parts of bismuth, and so exceedingly fusible as to melt below the temperature of 160° Fahr. A brief description of another alloy, similar in character and scarcely less remarkable, is herewith submitted; it consists of cadmium, one part; lead, six parts; bismuth, seven parts. This alloy melts at about 180° Fahr., being nearly midway between the melting-point of the old fusible metal, consisting of the three metals, tin, lead, and bismuth, and that of the alloy first mentioned, consisting of the four metals, cadmium, tin, lead, and bismuth. It is remarkable, as exhibiting the liquefying property of cadmium in certain combinations; also in the fact that, while the mean melting-point of the constituents composing it is much higher than that of those composing the old fusible metal, it melts at a much lower temperature, being more fusible than any other alloy yet known consisting of but three metals. It has a clear, brilliant, metallic lustre, that does not readily tarnish. Its colour is a bright bluish grey, resembling platinum; when cast, its free surface presents a white frosted appearance. It is very flexible in thin plates, and breaks with a hackly fracture; but when thicker bars are broken, the fracture is smooth, resembling that of tempered steel. It is malleable, but not perfectly so. Its hardness is about the same as bismuth, and about the same as an alloy of two parts of lead and one part of tin or coarse solder, which it more nearly resembles in other respects. It may be that more approved methods of measuring temperature will give

the alloy a still lower melting-point than above ascribed to it, as I see that the experiments made by Lipowitz with my fusible metal indicate for it a much greater fusibility than my measurements."

The improved processes for the manufacture and metallurgy of *platinum*, by M. St. Claire Deville, are now generally known to the scientific public. The process is based upon the employment of a gigantic oxy-hydrogen blowpipe playing upon the metal in a nearly closed chamber cut out of lime, and was almost immediately upon its introduction adopted by the firm of Johnson, Matthey, & Co., the well-known precious metal refiners, who have since used it largely in the manufacture of platinum. They have recently availed themselves of the presence in England of M. Deville and other eminent scientific men to invite a party of English and Continental *savans* to witness one of the grandest metallurgical feats ever accomplished,—the melting and casting of a mass of pure platinum weighing upwards of 2 cwt. This mighty ingot of precious metal, by far the largest mass ever before obtained in a single lump, and worth £3,840, has recently been deposited in the International Exhibition. The mould into which it was run was roughly built up of refractory limestone; and the extreme fluidity of the liquid metal is well illustrated by the irregularities in the sides of the ingot, it having entered the minutest crevices between the lumps of stone as if it had been so much water. The sharpness of the impression, and the minute details which the melted metal has retained on solidifying, show that platinum, when once obtained in a fluid state, is as eminently adapted for fine castings as any of the commoner metals. We regret to add, that the vapour of osmic acid was given off so abundantly in this operation as to seriously affect M. St. Claire Deville, who superintended the fusion. He was obliged to return to Paris, where he for some days suffered severely.

PHOTOGRAPHY.

THE duties of the jury in Class 14, Photography, in the International Exhibition, are likely to be very onerous, on account of the large assortment of excellent photographs and apparatus displayed, not only in the British Department, but throughout all, or a large majority, of the foreign and colonial courts. The art of photography constitutes one of the chief efforts of science which has advanced with giant strides since the period of the Exhibition of 1851. With the introduction of the collodion process, which dates from the latter part of that year, and was actually employed by its inventor, Mr. Archer, within the building in Hyde Park, so much has been already accomplished that the World's Mart teems with innumerable examples of its successful application. The records of astronomical and meteorological phenomena, the adaptation to portraiture and to the illustration of foreign races, their manners and customs, remarkable landscape scenery, and the characteristics of distant regions,—on every side the visitor to the International Exhibition is reminded of the vast importance of photography, and of the attention it must have received during the intervening ten years. We are enabled to admire the results of our continental rivals, and to compare the life-size portraits of Mr. Mayall and other British exhibitors with those taken by M. Hansen, of Copenhagen.

The excellent photographs of MM. Ghémar Frères, and of Oehme and Jamrath, of Berlin, and the panoramic views of Florence, are well worthy of close inspection; and there is much to admire also in the way of photographic apparatus and chemicals of foreign manufacture, especially the cameras of M. Emile Busch, of Potsdam, and the monster sample of finely crystallized pyrogallic acid sent by M. Schering, of Berlin.

The expenditure of silver in the photographic processes has been lately made the subject of investigation by Mr. W. T. Mabley, who has communicated the results of his experiments to the Manchester Photographic Society. It appears that in the preparation of a full-sized sheet of sensitized albumen paper no less than sixty grains of nitrate of silver are withdrawn from the solution when of the strength of seventy grains to the ounce of water; but by careful management a very large proportion of this amount may be recovered in the form of insoluble salts of silver, such as the chloride and sulphide, which may again be reduced to metal. Mr. Mabley states, as the result of his operations upon fifteen sheets of albumenized paper, that he succeeded in collecting 350 grains of chloride of silver from the nitrate washings of the prints, and 180 grains of metallic silver reduced from the hyposulphite fixing-bath. If from these numbers the average saving be calculated, it will be found that more than three-fourths of the silver originally employed in the preparation of the paper should be recovered in the form of residues. In the course of his statement, Mr. Mabley describes a novel method of detecting and precipitating small quantities of silver from the hyposulphite solutions. It consists in adding caustic soda until alkaline, and boiling with a little grape-sugar, when the least trace of silver in the liquid will manifest its presence by the formation of a metallic deposit of reduced silver.

A series of comparative experiments are recorded in the "American Journal of Photography," which have for their object the determination of the relative degrees of sensitiveness possessed by albumenized paper which has been treated with the plain nitrate and with the ammonio-nitrate of silver. Paper prepared with the latter agent is shown to be more readily affected by light, and easily toned; but there are, at the same time, some disadvantages attending the employment of ammonio-nitrate of silver with albumen, in consequence of which it is recommended to sensitize the paper by floating upon a neutral solution of nitrate of silver, and afterwards to expose the dry sheets to the fumes of concentrated ammonia in a large glass bottle or cylindrical jar.

The American operators have likewise been experimenting upon new materials for the construction of the dipping-bath used in the collodion process. Glass, porcelain, gutta-percha, and, more recently, ebonite, have been successfully employed; but the last idea is to try the application of wood: the result has proved a failure on account of the decomposing action exerted by the salts in the wood upon the solution of nitrate of silver.

It is the common misfortune of photographers to experience a difficulty in preserving the nitrate bath in the most sensitive condition, without exhibiting a tendency to produce "fogging" on the development of the collodion picture; and when this condition is practically realized, the most trivial disturbing cause will often overturn that nice degree of neutrality

upon which the successful result so much depends. In order to restore to proper working order a bath which exhibits these erratic properties we should do well in following the instructions of Mr. Divine. The silver solution is to be transferred to a glass vessel, and freely exposed to the sun's rays, when any contamination arising from the presence of oxidizable organic matter, or from an excess of the oxide of silver itself, is quickly destroyed with reduction of dark-grey metallic silver; at this stage a small quantity of a dilute solution of common salt is introduced, which will have the effect of carrying down with it these finely-divided particles, which no ordinary filter is capable of separating. After thorough agitation the liquid may be filtered, and the clear solution returned to the dipping-bath.

The preparation of pure nitrate of silver for photographic purposes is in some cases facilitated by employing ammonia as a means of separating traces of copper from reduced metallic silver. In proceeding to make use of this plan, the silver and copper alloy (standard silver) is to be dissolved in nitric acid, and the clear solution precipitated by common salt, when a moderately pure form of chloride of silver is obtained after careful washing. This precipitate is then dissolved in ammonia, and again thrown down in the state of reduced metallic silver by the action of a rod of copper; by washing now this finely-divided silver with dilute ammonia, every trace of copper is removed, and the pure metal may be dried and dissolved at once in nitric acid; the solution being either evaporated to the crystallizing point, or carried to dryness and partially fused, to furnish the neutral description of nitrate of silver.

The use of the proto-salts of iron, as developing agents in the collodion process, appears once more to be gaining the ascendancy over pyrogallic acid. M. Adolphe Martin has given an excellent suggestion for the removal of the small quantity of free sulphuric acid which is usually contained in the crystals of proto-sulphate of iron, and which interferes with the production of delicate half-tones when this agent is used in the preparation of a developing solution.

Acetate of lead is weighed out in the proportion of one part to four of the sulphate of iron, and these salts being separately dissolved in water are mixed, when a heavy precipitate of sulphate of lead is formed with production of an equivalent amount of the acetate of iron. Under these conditions it is impossible for any free sulphuric acid to exist in the solution; a small quantity of acetic acid will be liberated, which serves a useful purpose in keeping the iron dissolved without hindering its developing qualities.

With a similar object, a writer from Elberfeld recommends the addition of nitrate of potash (saltpetre) to the sulphate of iron developing solution. This expedient was, however, suggested as far back as 1853, in the "Journal of the Photographic Society," by Mr. Spiller, who described this as a ready means of preparing a solution having all the properties of the proto-nitrate of iron, and capable of developing the half-tones in great perfection.

PHYSICS.

LIGHT, PHOSPHORESCENCE, AND HEAT.

THE subject of prismatic analysis still continues to attract attention. Dr. W. A. Miller has been lecturing on this subject to the Pharmaceutical Society of London, and Dr. Roscoe at the Royal Institution of London and elsewhere.

Some degree of variability, if it may be so expressed, has been observed by several investigators in the *spectra of the earthy alkalies*, on subjecting those substances to high and variable temperatures, and this variation has been examined by Professors Roscoe and Clifton, and the explanation they suggest of this variation is, that at the temperature of a gas-flame the spectrum of the *oxide* of the substance is seen, whilst at the higher temperature of the voltaic arc the oxide is decomposed and the spectrum of the elementary substance itself is seen.

M. Morren has been examining the *phosphorescence of rarefied gases* and finds,—1st, that pure and dry oxygen, however rarefied, is never phosphorescent by the passage of electric sparks; 2nd, that any other gas, whether simple or compound, if pure and rarefied, never shows the phenomenon of phosphorescence; 3rd, a mixture of oxygen and nitrogen exhibits feeble and transient phosphorescence, and more distinctly if a little vapour of ordinary nitric acid is added; but if a small quantity of either fuming or anhydrous sulphuric acid is added, the phosphorescence is splendid and durable; 4th, a similar beautiful result is obtained by passing induction sparks through a rarefied mixture of 200 parts oxygen, 150 sulphurous acid, and 100 nitrogen; and, 5th, the phosphorescence is produced by the decomposition and recomposition of the crystallized body produced in the manufacture of oil of vitriol; viz., NO^3, $2\ SO^3$. Anhydrous sulphuric acid is probably the seat of this luminosity.

The subject of phosphorescence has also been recently investigated by M. O. Fiebig, particularly with regard to the influence of heat upon this property of bodies. He has found that when a solution of aesculine is gradually heated, the blue tint first becomes deeper and more violet, then it becomes paler, and at about 50 degrees it can hardly be distinguished from the ordinary tint. By further heat, the tint lessens in intensity and becomes pale green, and that, with a solution of quinine similarly treated, the tint lessens in intensity as it approaches the boiling-point; and, in both liquids, cooling reproduces the original colour. He also found that fluoride of calcium possesses the property of becoming phosphorescent by the action of heat after a previous insolation, and that this property remains after the loss of colour.

Professor Rankine, of Glasgow, has described, in the *Philosophical Magazine*, a dew-bow, which he saw on the surface of mud, in a by-road near Glasgow, on the 13th of February last; he states, "that its colours were complete from red to violet, and very bright and distinct, especially where the mud was softest and moistest; where a sheet of water, how thin soever, covered the mud, the iris vanished. No trace of an iris could be seen on the grass, in the sky, or anywhere but on the mud; and on those

parts of the turnpike-road where the mud had been much disturbed no iris was visible."

A French Academy Commission, composed of Becquerel, Despretz, Combes, and Pouillet, have recently examined and commended M. Serrin's newly-invented regulator for electric lights.

Heat.—No. 12 of Poggendorff's "Annalen" contains an article "On the Passage of Radiant Heat through Moist Air," by Professor Magnus, and this paper has been translated and published in the *Philosophical Magazine*. The author states that "neither by the application of a source of heat of 100, nor by using a strong gas-flame, could any difference be perceived in the transmission of heat through air, whether it was dry or saturated with vapour." In consequence of results contradictory to these having been obtained and published by Dr. Tyndall, the author has repeated his experiments and reiterates his former statement, "that aqueous vapour, so long as it is not separated as fog, exercises at 15 C° no appreciable influence on the transmission of thermal rays, and that the rays of the sun, so long as the air is clear, reach the earth in the same manner, whether the atmosphere is saturated with vapour or not." Dr. Tyndall explains, in a succeeding paper in the *Philosophical Magazine*, the manner in which he considers the difference of the results in the two cases occur.

Drs. Matthiessen and Von Bore, in their experiments "On the Influence of Temperature on the Electric Conductivity of the Metals," have come to the conclusion that "all pure metals, in a solid state, vary in conducting power to the same extent between 0 and 100 C," and that "metalloids conduct electricity better when heated than when cold."

ZOOLOGY.

THE *Hominal Kingdom.*—Dr. Fée, of Strasbourg, has entered into a controversy with M. De Quatrefages, who was supported by the recently deceased Isidore Geoffroy St. Hilaire, with respect to the separation of *man* from the other mammalia, which was suggested by the last-named, on the ground that Man possesses moral and religious sentiments (*moralité et religiosité*) which are peculiar to him, and are possessed by no other animal. Dr. Fée adopts the position, that if the intellectual faculties were to be taken as a standard, it would be necessary to re-classify the whole animal kingdom; insects would have to be placed before fishes, birds before most mammals, &c. He argues that it is not proved that the brain of man is different in its character from that of animals; that some men are hardly more capable of education than some animals, and, therefore, that a human kingdom is inadmissible.

European Apes.—The Rev. A. C. Smith, having recently visited Spain, made particular inquiry concerning the presence of the Barbary ape (*Macacus inuus*) upon the rock of Gibraltar. Undeceived by the incredulous tone of a French skipper, who professed that no such animals existed, he applied for information to the signal-man posted at the top of the rock. This man declared having seen them that very morning "on the move,"

the shifting of the wind inducing them to seek the most sheltered side of the rock. They appear to feed upon the sweet roots of the palmetto (*Chamærops humilis*) and on beetles and other insects. Their numbers, however, are rapidly decreasing, and unless means are soon taken to perpetuate their race upon the rock of Gibraltar, the quadrumana will speedily cease to be a European order. For some years past they have been watched, and the register shows that their numbers, which amounted to ten in 1856, are now reduced to four, which there is reason to believe are, moreover, all of the same sex.

The Gorilla.—The wonderful adventures of M. du Chaillu in Equatorial Africa having been for a brief period the all-absorbing topic, have, like other nine-days' wonders, subsided into their proper place. The retirement of M. du Chaillu himself from the field of controversy has allowed judgment to go by default, and the reception given to his book by those traders upon the Gaboon who are best capable of judging of its merits and credibility, has gone far to aid the public in forming a correct estimate of the matter. A letter in the *Times* of June 3rd, forwarded by Sir R. Murchison, revives the subject; but, being only a general testimonial of previous good conduct, it has but little bearing upon the present issue, and the evidence brought forward is only of a negative kind. At the same moment, by a curious coincidence, Mr. R. B. Walker has arrived from the Gaboon, bringing with him some most remarkable remains of the giant ape, which we have had the pleasure of inspecting in the Liverpool Museum. These consist of a head, hand, and foot, preserved in spirits, which give a more correct idea of the formidable character of the animal than any specimens hitherto exhibited. The head measures fourteen inches from the muzzle to the nape, and the hand and foot must be seen to be appreciated. They are destined for the British Museum. The monster to which they belonged must have stood six feet high. Two skeletons have been generously presented by Mr. Walker to the Liverpool Museum. The thigh-bone of one of these measures sixteen inches and a quarter in length, or two and a half inches more than that of the individual so well known to the public as the "King of the Gorillas." A young specimen, preserved in spirits, was also brought over, which was taken alive, and it was fondly hoped would be the "lion" of the Zoological Gardens this season.*

* Since the above was written, another gorilla (dead) has arrived at Liverpool from the Giboon, and will probably be added to the zoological treasures of the town museum.

M. de Chaillu has an illustration in his book which represents himself and a number of blacks contemplating a fallen gorilla. One day last month we could have presented him with a companion picture.

On the floor of the sale-room of a Liverpool broker, to whose care the corpse of the illustrious visitor was confided, there stood a box-coffin, about five feet long, containing its skeleton (the animal itself is 5 feet 11 inches high, the skeleton not being stretched at full length), and by its side lay the skin; the hands exceeding in size, and resembling in appearance, a large pair of gloves with external fur, and bare skin on the palm, &c. All round stood a number of curious and wondering "Liverpool gentlemen," brokers, and merchants, with open eyes and *closed nostrils;* whilst Mr. Moore, the curator of the

Birds of Paradise.—These wonderful birds, inhabitants of the inaccessible and dangerous swamps of New Guinea, have at length been comfortably located in the Zoological Gardens of London. One specimen only had previously been known in this country, which many years since lived at Windsor, as a pet of the late Princess Augusta. For the present grand addition to the unrivalled collection in the Regent's Park, the society and the public are indebted to Mr. A. R. Wallace, well known in connection with his zoological explorations. With infinite difficulty he succeeded in procuring two specimens, both males unfortunately, of the *Paradisea papuana*, which have been transported safely, and deposited in the gardens in a healthy condition. The loveliness of the plumage of these birds is no guarantee of sweetness of voice, and their harsh *caw* is said to resemble that of the crows, to which family they are nearly allied.

The Pythoness.—Since the arrival of the Hippopotamus, no animal has caused so general an interest as the female Python, which was long busily engaged in incubating her pile of eggs. We abstained from noticing it in our last number, preferring to await the result. The Indian Python (*Python bivittatus*), which, in 1841, hatched eight of its eggs at Paris, incubated fifty-six days, and the careful observations made on that occasion are interesting as compared with the recent event. Our python deposited its eggs on the 13th January, and commenced at once its self-imposed duties. Having sat for six weeks without taking food, the animal came off on the 4th of March, for the purpose of changing its skin, and remained all night away from her eggs. Towards the end of March, after the reptile had been nine weeks upon the eggs, it was deemed desirable to remove them, which was done with much difficulty, when it was found that they were entirely decomposed, so much so as to render it impossible to say how long they had lost their vitality, though they are believed to have been impregnated. The whole circumstance is extraordinary, and not the least remarkable part of it is the increased temperature evolved by the reptile during the process, to all appearance for the purpose of vivifying the eggs. M. Valenciennes states, that in the case of the Indian Python at Paris, a special heat was developed, which gradually *diminished* as the eggs approached hatching. Although the experiment in the recent case was incomplete, Dr. Sclater is of opinion that this view is not confirmed. The fact, however, of a special heat attributable to the process of incubation is undoubted. The male and female python were both kept in the same den, the temperature of which varied from 58° to 66°. The temperature of the male was usually between 10° and 11° above this, while the tempe-

museum, was, in a most business-like manner, measuring the monster's proportions as he lay in his narrow coffin.

Our broker-friend informed us, that "if this sample is approved, a regular supply will be forthcoming;" so we recommend M. du Chaillu to "realize," if he has any stocks on hand.

The animal above referred to killed the native who inflicted the mortal wound. The black speared him in the breast, and approaching too soon to withdraw the spear, was seized by the gorilla, and instantly squeezed to death in his terrible embrace.

We hope shortly to be able to communicate further details concerning the habits of these animals.

rature, as ascertained by a thermometer placed between the coils of the female in the beginning of March, was as much as 20° above that of the male. The pythoness has abstained from food for the enormous period of thirty-six weeks.

Bite of the Adder.—It is not often we hear of fatal effects resulting from the bite of our indigenous snakes. The *British Medical Journal* quotes a case from the *Sussex Express*, of a little boy, who, not being properly attended to, is said to have succumbed to the poison on the second day.

Parthenogenesis of the Honey-bee.—Mr. T. W. Woodbury, of Mount Radford, Exeter, has confirmed the theory first propounded by Dzierzon of Karlsmarkt, that a Virgin Queen can breed drones. The *Journal of Horticulture* of October 22 contains an account of his experiments which appear to be perfectly conclusive.

New Animals.—No division of the animal kingdom yields so many novelties as the classes of birds and insects. Mr. G. Lawrence describes six new species of birds from Panama, belonging to the families of thrushes and shrikes. Dr. Jerdon has met with several new species in Upper Burmah. Dr. G. Hartlaub has described several new species from Cape Colony; and Mr. J. H. Gurney, M.P., from Natal, while the indefatigable Dr. Sclater, in whose "Ibis"* the above may be found, has not been idle. Mr. Arthur Adams continues his contributions to the Molluscan Fauna of the Sea of Japan. Mr. Bates, well known for his zeal in collecting insects, still enriches the list of longicorn beetles inhabiting the valley of the Amazons; and Mr. T. V. Wollaston, of Madeiran fame, has extended his researches to the coleoptera of the Canary Islands. Several new fishes have also been obtained from the Pacific coast of central America.

New and rare British Animals.—The British fauna, far from being exhausted, continues to receive accessions in various departments. It is interesting to observe, that the most predacious of our quadrupeds is not yet extinct, the wild cat having been recently met with on the property of the Earl of Seaforth, in Inverness-shire. The skull of a new species of Pilot-whale (*Globiocephalus*), dredged up at Bridport, Dorsetshire, has been described by Dr. Gray, and figured in the "Annals of Natural History." The rare and beautiful Crane (*Grus cinerea*) has been recently met with (and, of course, *killed*) near Hartlepool. Mr. O. Pickard, Cambridge, the indefatigable spider-hunter, has added ten new species to the British list, and the veteran zoophytologist Joshua Alder has made large additions to the list of Hydroid Zoophytes by his explorations on the coast of Northumberland.

Mesozoic Forms of Life in Australia.—Under this title Professor Owen announces the very interesting fact of the discovery by the dredge, in eight fathoms, of a living encrinite, of a rose-pink colour, fading to white; whose stem, attached to a stone, was six inches long, the arms one and a half inch. This remarkable animal was found by Mr. J. S. Poore in King George's Sound, Western Australia.

The Zoological Collections in the British Museum, it has been decided, shall *not* be removed to South Kensington, according to the proposals of Professor Owen. Mr. Osborne placed the Professor's plans in so obnoxious a light, that

* We recommend the "Ibis," an ornithological journal, edited by Dr. Sclater, to our naturalist readers.

the question was negatived in the House, and the Government defeated by the unusually large majority of 92.

Faunal Collections.—Professor Agassiz, in a report to the Senate and House of Representatives, urges the importance of special district collections to facilitate the study of the species, and their geographical distribution. These collections, he says, bring distinctly before the eye the character of the inhabitants of different parts of the world in their natural combinations, and that in a far more impressive manner than could possibly be attained by a mere nominative enumeration of species.

Death of Schrœder Van der Kolk.—This eminent physiologist, Professor of Medicine in the University of Utrecht, expired on May 1st. He was highly esteemed in Holland, and a member of several illustrious orders of knighthood. A letter, describing the event, says of him: "Utrecht has thereby lost one of its most estimable citizens, the University one of her ornaments, society one of her greatest benefactors, science one of her most devoted cultivators, his numerous household a loving father, their mainstay and their hope!"

LIST OF ENGLISH AND FOREIGN POPULAR WORKS ON SCIENTIFIC SUBJECTS, PUBLISHED DURING THE YEAR ENDING JULY 1, 1862.*

Astronomy :—

*Barrol's, J. A., "Atlas of Cosmos," with plates, in parts, folio. (French.)

*Biot's, J. B., "Studies in Indian and Chinese Astronomy." (French.)

Chambers's, G. F., "Handbook of Descriptive and Practical Astronomy." Post 8vo. Murray.

Drayson's, Capt., "Common Sights in the Heavens," &c. Chapman & Hall.

Lewis's, Sir G. C., "Historical Survey of the Astronomy of the Ancients." Parker, Son, & Bourne.

*Guérin's "Indian Astronomy, according to the Doctrines and Writings of the Brahmins, with an Explanation of the Chief Astronomical Monuments of Egypt and Persia." Plates. 8vo. (French.)

*Maedler's, J. H. V., "Total Eclipses of the Sun, with especial Reference to the Eclipse of July 18, 1860." 9 plates. (German.)

Mitchell's, O. M., "Orbs of Heaven," and "Popular Astronomy." Crown 8vo. Routledge.

Read's, W. T., "Popular and Mathematical Astronomy, with Formulæ of Trigonometry." Crown 8vo. Longman.

†Stehr, L., on "The System of the World."

Botany :—

Archer's, T. C., "Vegetable Products of the World in Common Use." Illustrated. Royal 16mo. Routledge.

Cooke's, M. C., "Manual of Structural Botany." Illustrated. 18mo. Hardwicke.

Cooke's, M. C., "Manual of Botanic Terms." Illustrated. Fcap. 8vo. Hardwicke.

Cooke's, M. C., "Plain and Easy Account of British Fungi." With 24 coloured plates. Fcap. 8vo. Hardwicke.

Grindon's, L. H., "Manual of Plants, British and Foreign." Pamplin.

Glenny's, George, "Properties of Fruits and Vegetables," "Guide to Judges," &c. Fcap. 8vo. Houlston.

*Hildebrand's "Distribution of Coniferæ, Recent and Fossil." Plates. (German.)

Macmillan's, "Foot-notes from the Page of Nature." Fcap. 8vo. Macmillan.

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* All works in this list marked with an asterisk (*) are advertised for sale by Messrs. Williams and Norgate, Henrietta-street, Covent Garden, in the language in which they are published abroad; those marked thus (†) are sold by Mr. D. Nutt, 270, Strand.

Darwin's, Chas., "Intercrossing of Orchids by Means of Insects." Murray.

*Maeller's, C., "Vegetable Kingdom." Illustrated. (German.)

†Moquin-Tandon's "Elements of Medical Botany."

*Schleiden's, M. J., "Elements of Scientific Botany." 250 wood engravings, 5 plates. (German.)

Seibert's "Popular Botany, in relation to Plants of the Forest; Economic, Technical, and Medical Botany." (German.) Leipsig: C. F. Winter.

Maling's, Miss E. A., "Indoor Plants; and how to grow them; for the Drawing-room, Balcony, and Greenhouse." Fcap. 8vo. Smith & Elder.

Lankester's, Mrs., "Wild Flowers worth Notice." Illustrated. Fcap. 8vo. Hardwicke.

Sowerby & Johnson's "British Poisonous Plants." Illustrated with 32 coloured plates. Post 8vo. 2nd edition. Van Voorst.

Chemistry:—

Heaton's, C. W., "Threshold of Chemistry." An Experimental Introduction. Post 8vo. Chapman & Hall.

Odling's, W., "Manual of Chemistry—Descriptive and Theoretical." 8vo. Longman.

Knapp's "Chemical Technology." Baillière.

*Hiller's "Manual of Chemistry." 150 engravings. (German.)

*Oppler's "Handbook of the Manufacture of Mineral Oils and Dyes from Coal, Wood, Turf, Petroleum, and other Bituminous Substances." (German.)

Meller's, D. W. A., "Elements of Chemistry." 2nd edition. Parker, Son, & Bourne.

Gmelin's "Handbook of Chemistry." 2nd edition revised. Harrison.

Piggot's, Dr. A. Mowden, "Chemistry and Metallurgy of Copper." New edition. Illustrated. 12mo. Philadelphia.

Thomson's, Dr. R. D., "School Chemistry. Practical Rudiments of the Science." 2nd edition. Fcap. 8vo. Longman.

Kirchoff's "Researches on the Solar Spectrum and the Spectra of the Chemical Elements." (Translated by H. E. Roscoe.) Macmillan.

Faraday's, M., "Lectures on the Chemical History of a Candle." Edited by W. Crookes. Fcap. 8vo. Griffin & Co.

Bowman's, J. E., "Practical Chemistry." Longman.

Geology, Mineralogy, Metallurgy, and Palæontology:—

Bristow's, Henry W., "Glossary of Mineralogy." Post 8vo. Longman.

Owen's, Richard, "Palæontology. A Summary of Extinct Animals." 2nd edition. 8vo. Black.

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Percy's, John, "Metallurgy: the Art of Extracting Metals from their Ores." 8vo. Murray.

*Delesse's "Studies on the Metamorphism of Rocks." (French.)

*Fremontel's "Fossil Polyparies," &c. 8vo. (French.) Paris.

*Leymerie's "Elements of Mineralogy and Geology." 12mo. (French.) Paris.

*Quenstedt on "The Epochs of Nature." 800 Engravings Royal 8vo. (German.)

*Unger's, F., "Views of the Ideal World;" edited by S. Highley. 4to.

Fairbairn's, Wm., "Iron: its History, Property, and Manufacture." Post 8vo. Black.

*Dechen's "Geological Guide to the Siebengebirge (Rhine)." (German.)

*Oldham's "Palæontologica Indica."

Smith's, A., "Blowpipe Character of Minerals." Edited by Houghton & Scott. 8vo. Williams & Norgate.

Pepper's, John H., "Playbook of Metals." New edition. Crown 8vo. Routledge.

Wauchope's, Admiral, "Proofs of the Cause and Date of the Boulder Drift." Black.

Jukes's, J. B., "Student's Manual of Geology." New edition. Illustrated. Crown 8vo. Black.

Scrope's, G. P. "Volcanoes; the Character of their Phenomena," &c. Revised and enlarged. 2nd edition. 8vo. Longman.

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*Meyer's, G., "Manual of the Psychology and Anatomy of Man." 356 plates. (German.)

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*Frarière's, De, "Material Influences during Gestation upon the Moral and Intellectual Predispositions of Children." (French.)

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†Emsmanor's "Elementary Physics." (German.)

*Schellen, H., "On the Electro-magnetic Telegraph." New edition. 252 engravings. (German.)

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*Burmeister's "Zoological Atlas." 2nd edition. (German.)

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